HAZWRAP

HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM

CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK

FINAL
REMEDIAL INVESTIGATION REPORT
VOLUME I OF III: TEXT

U.S. AIR FORCE
INSTALLATION RESTORATION PROGRAM
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

OCTOBER 1992

prepared by
HALLIBURTON NUS
Environmental Corporation

Prepared for
HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
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technologies and services for a cleaner and safer world

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AA	Atomic Absorption
AFB	Air Force Base
AFLC	Air Force Logistics Command
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
BCFs	Bioconcentration Factors
BOD	Biochemical Oxygen Demand
BW	Body Weight
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CI	Contaminant Indicators
CLP	Contract laboratory Program
COD	Chemical Oxygen Demand
CRDL	Contract Required Detection Limit
cm	Centimeter
CSF	Cancer Slope Factor
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DERP	Defense Environmental Restoration Program
DOD	Department of Defense
DOE	Department of Energy
DQOs	Data Quality Objectives
ED	Exposure Duration
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	Environmental Protection Agency
ft	Feet
GC/MS	Gas Chromatography/Mass Spectrometry
gpm	Gallons Per Minute

ACRONYMS AND ABBREVIATIONS (CONTINUED)

HALLIBURTON NUS	HALLIBURTON NUS Environmental Corporation
HAZWRAP	Hazardous Waste Remedial Actions Program
HPLC	High Pressure Liquid Chromatography
ICP	Inductively Coupled Plasma
IRP	Installation Restoration Program
Kg	Kilogram
l	Liter
LOAEL	Lowest Observed Adverse Effect Level
LQAP	Laboratory Quality Assurance Plans
MCL	Maximum Contaminant Level
MBAS	Methylene Blue Active Substance
MCLG	Maximum Contaminant Level Goal
mg	Milligram
MSL	Mean Sea Level
MW	Monitoring Well
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NTU	Nephelometric Turbidity Units
OC-ALC	Oklahoma City Air Logistics Center
PAH	Polynuclear Aromatic Hydrocarbon
PARCC	Precision, Accuracy, Representativeness, Comparability and Completeness
PCB	Polychlorinated Biphenyl
PDS	Post Digestion Spike
PE	Performance Evaluation
QA/QC	Quality Assurance/Quality Control
QAPP	HALLIBURTON NUS Quality Assurance Project Plan

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RPD	Relative Percent Difference
SD	Sediment Sample
sec	Second
SVOC	Semivolatile Organic Compounds
SW	Surface Waste
TAL	Target Analyte List
TCL	Target Compound List
TOC	Total Organic Carbon
TOX	Total Organic Halogens (water)
ug	Micrograms
U.S.	United States
USAF	United States Air Force
USACOE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geologic Survey
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This Remedial Investigation of Crutcho and Kuhlman Creeks and tributaries of Elm Creek has been performed in support of the U.S. Air Force Installation Restoration Program at Tinker Air Force Base. This investigation was performed after a previous investigation documented the presence of organic compounds in storm sewer outfalls discharging to Crutcho and Kuhlman Creeks.

The principal objectives of this investigation were to (1) confirm the presence or absence of contaminants in creek sediments and surface waters on and contiguous to Tinker Air Force Base, (2) determine the nature and extent of contaminants, if present, and (3) evaluate the actual and/or potential risk to the public health and the environment.

Tinker Air Force Base is located southeast of Oklahoma City, in central Oklahoma. Crutcho Creek originates south of Tinker Air Force Base and flows northward through the base, toward the North Canadian River. Kuhlman Creek, a tributary of Crutcho Creek, originates in the northern portion of the base. Elm Creek originates in the southern portion of the base and flows south toward the South Canadian River.

Sediment and surface water samples were collected from Crutcho and Kuhlman Creeks, and tributaries of Elm Creeks in two separate field phases, baseline and confirmation data collection. Baseline field activities were conducted in July and October 1991. Sediment and surface water samples were collected from 27 locations and analyzed for a broad spectrum of organic and inorganic compounds and contaminant indicators. Confirmation data collection was performed in February and May 1992. Sediment and surface water samples were collected from 11 creek locations in February 1992 to better define the nature and extent of contaminants identified during the July 1991 baseline field effort. Two of these samples were collected upstream of Tinker Air Force Base to establish background conditions. In May 1992, surface water samples were re-collected from 7 of the 11 locations sampled in February 1992, to monitor seasonal variations in contaminant release.

The majority of sediment samples collected in July 1991 and February 1992 did not contain significant quantities of organic compounds. One sediment sample near the northern base boundary on Kuhlman Creek did contain a polychlorinated biphenyl, Aroclor-1260, at detectable concentrations in July 1991 and February 1992. Only one pesticide, 4,4-DDD, was detected in a sediment sample from Crutcho Creek in February 1992. Two sediment samples from Kuhlman Creek and two samples from Crutcho Creek contained detectable concentrations of semivolatile organics, primarily nine polynuclear aromatic hydrocarbons.

Inorganic compounds were detected in all sediment samples from all three creeks. The inorganics that occurred most often included arsenic, barium, chromium, copper, lead, vanadium, and zinc. Background samples from Crutcho Creek contained the highest concentration of barium and lead.

The surface water in Crutcho and Kuhlman Creeks and tributaries of Elm Creek did not contain significant quantities of organic compounds. One sample from Kuhlman Creek did contain two semivolatile organic compounds, bis(2-ethylhexlyl)phthalate and di-n-octyl phthalate. The concentration for bis(2-Ethylhexyl)phthalate exceeded the Federal Maximum Contaminant Level. One volatile organic compound, xylene, was also detected (4 ug/l) in a surface water sample from Kuhlman Creek. Two volatile organic compounds, acetone and 4-Methyl-2-pentanone, were detected at low levels in each surface water sample collected in May 1992. One surface water sample collected in May 1992 from Kuhlman Creek contained a low concentration (6.1 ug/l) of the pesticide, chlorpyrifos. No other pesticides or polychlorinated biphenyls were detected in surface water samples.

Inorganics were detected in the surface water from all three creeks and tributaries, but all inorganic concentrations were below the Federal Maximum Contaminant Levels. Detected inorganics included arsenic, barium, calcium, cobalt, lead, magnesium, mercury, sodium, and zinc.

The information generated from the baseline and confirmation data collection activities was used to perform a risk assessment based on current U.S. Environmental Protection Agency guidelines. The objective of this assessment was to determine whether the sediments and/or surface waters in Crutcho and Kuhlman Creeks or the tributaries of Elm Creek at Tinker Air Force Base present any unacceptable public health or environmental risks.

The results of the risk assessment for surface water and sediment scenarios did not indicate any unacceptable carcinogenic or noncarcinogenic risks associated with the designated beneficial uses of Crutcho and Kuhlman Creeks or tributaries of Elm Creek. The Hazard Indices associated with the ingestion of surface water by child residents exceeded unity at several locations on Crutcho and Kuhlman Creeks; however, since these streams are not classified for use as potable water supplies (Oklahoma Water Quality Standard) these are hypothetical risks not based on the designated uses of these streams. In addition, since the Hazard Index for all target organs was less than unity and the largest component of the Hazard Index is associated with what is interpreted to be naturally occurring barium, these indices are not considered indicative of unacceptable health risks. The highest carcinogenic risk calculated (1.6×10^{-6}) for the surface water scenarios was for ingestion of fish at Location 1 on Kuhlman Creek. This risk is well within the USEPA risk range goal of 10^{-4} to 10^{-6}

and is based on a worst-case scenario that does not take into consideration the size of the stream and its limited fish population.

Arsenic concentrations exceed the Oklahoma Water Quality Standard criteria for the consumption of fish (1.399 ug/l) at several locations in Crutcho and Kuhlman Creeks and tributaries of Elm Creek. Arsenic concentrations detected in the tributaries of Elm Creek also exceeded Oklahoma's water quality criteria for fish ingestion and potable water use (0.175 ug/l). Since the average background level of arsenic was measured to be 1.15 ug/l, these exceedances are not felt to be indicative of site-specific contamination but may reflect regional use of arsenical pesticides and elevated naturally occurring background levels.

The observations and findings of this investigation provided the rationale for the following recommendations:

- A surface water monitoring program should be established to sample Crutcho and Kuhlman Creeks at both upstream and downstream base boundaries. Periodic monitoring of these locations will identify significant changes in water quality and will document if the changes are due to activities at Tinker AFB or are due to off-base sources.

- An oil/water separator, a surface water detention structure or other spill containment measures should be considered for use on Crutcho and Kuhlman Creeks. The construction of the Navy Facility in the Crutcho Creek drainage area increases the potential for a future spill or leak that could cause off-site damages. On Crutcho Creek, one of the existing concrete floodwater detention structures could potentially be used for this purpose.

1.0 INTRODUCTION

1.1 BACKGROUND

The United States Air Force (USAF), because of its primary mission in defense, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. These operations dealing with hazardous materials have been recognized by the Department of Defense (DOD) and action has been taken to identify the locations and contents of past disposal sites on DOD installations and to eliminate the hazards to public health posed by the sites in an environmentally responsible manner. The DOD program is called the Defense Environmental Restoration Program (DERP). The Air Force component of the program is the Installation Restoration Program (IRP).

Current policy for the IRP is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated December 11, 1981 (Department of Air Force 1981). Initial IRP guidance (DEQPPM 81-5) was published and implemented for Air Force properties in January 1982 and the IRP Guidance Manual was last revised in March 1991.

The overall objectives of the IRP are to confirm the presence or absence of contamination, evaluate the potential for contaminant migration, and conduct remedial measures, if necessary. The terminology and procedures for the IRP are consistent with other national hazardous waste cleanup programs and the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300).

1.2 AUTHORITY

The Department of Energy (DOE) has entered into an interagency agreement with the Air Force Logistics Command (AFLC) to provide technical assistance to the IRP effort through Martin Marietta Energy Systems, Inc. (Energy Systems). The Energy Systems program responsible for IRP oversight is the Hazardous Waste Remedial Actions Program (HAZWRAP). This Remedial Investigation (RI) Report has been prepared by HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS) for Tinker Air Force Base (AFB) under contract to HAZWRAP in response to General Work Order Number 91B-99784C, Task Work Order Y-04, dated September 7, 1989.

1.3 PURPOSE AND SCOPE

The purpose of this report is to present the results of the RI conducted by HALLIBURTON NUS for Crutcho and Kuhlman Creeks and tributaries of Elm Creek within and contiguous to Tinker AFB. The

RI was performed to (1) confirm the presence or absence of contamination, (2) determine the nature and extent of contaminants present, and (3) quantitatively evaluate whether the contamination, if present, poses a threat to human health or to the environment. This report includes general background information, a description of investigative activities, data collected during the field investigations, the analytical program, results of the risk assessment, and recommendations regarding the future disposition of the site.

1.4 INSTALLATION LOCATION AND DESCRIPTION

Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area. Figure 1-1 illustrates the general location of Tinker AFB within the State of Oklahoma. The base covers 5001 acres and is surrounded by suburban residential and commercial development to the north, west, and east, with industrial and commercial development to the south. Crutcho and Kuhlman Creeks are located in the northern, western, and southern portions of the base. The tributaries of Elm Creek are in the southeast portion of the base. Figure 1-2 is a site location map showing Crutcho and Kuhlman Creeks and the tributaries of Elm Creek.

1.5 BASE HISTORY

The initial construction of Midwest Air Depot (i.e., Tinker AFB) began in July 1941. The base was activated in March 1942. During World War II, the depot was responsible for reconditioning, modifying, and modernizing aircraft, vehicles, and equipment.

In 1948, Tinker AFB became a worldwide repair depot for several aircraft and many other weapons and engines. The level of activity has fluctuated during the history of the base, but the primary mission has not changed. Tinker AFB remains a major industrial complex for overhauling, modifying, and repairing military aircraft.

Tinker AFB also has a multifold flying mission consisting of logistics, administrative flight support, and pilot proficiency training. Production flight checks of aircraft that have undergone depot maintenance, repair, and/or modification comprise the major portion of the logistic flight support mission. The 552nd Airborne Warning and Control Wing includes training flights as well as support of Tactical Air Command's worldwide mobile strike force. The 301st Tactical Fighter Wing (Reserves) performs tactical fighter training in F-16 aircraft. The reserve unit maintains combat proficiency and readiness of its personnel and aircraft.

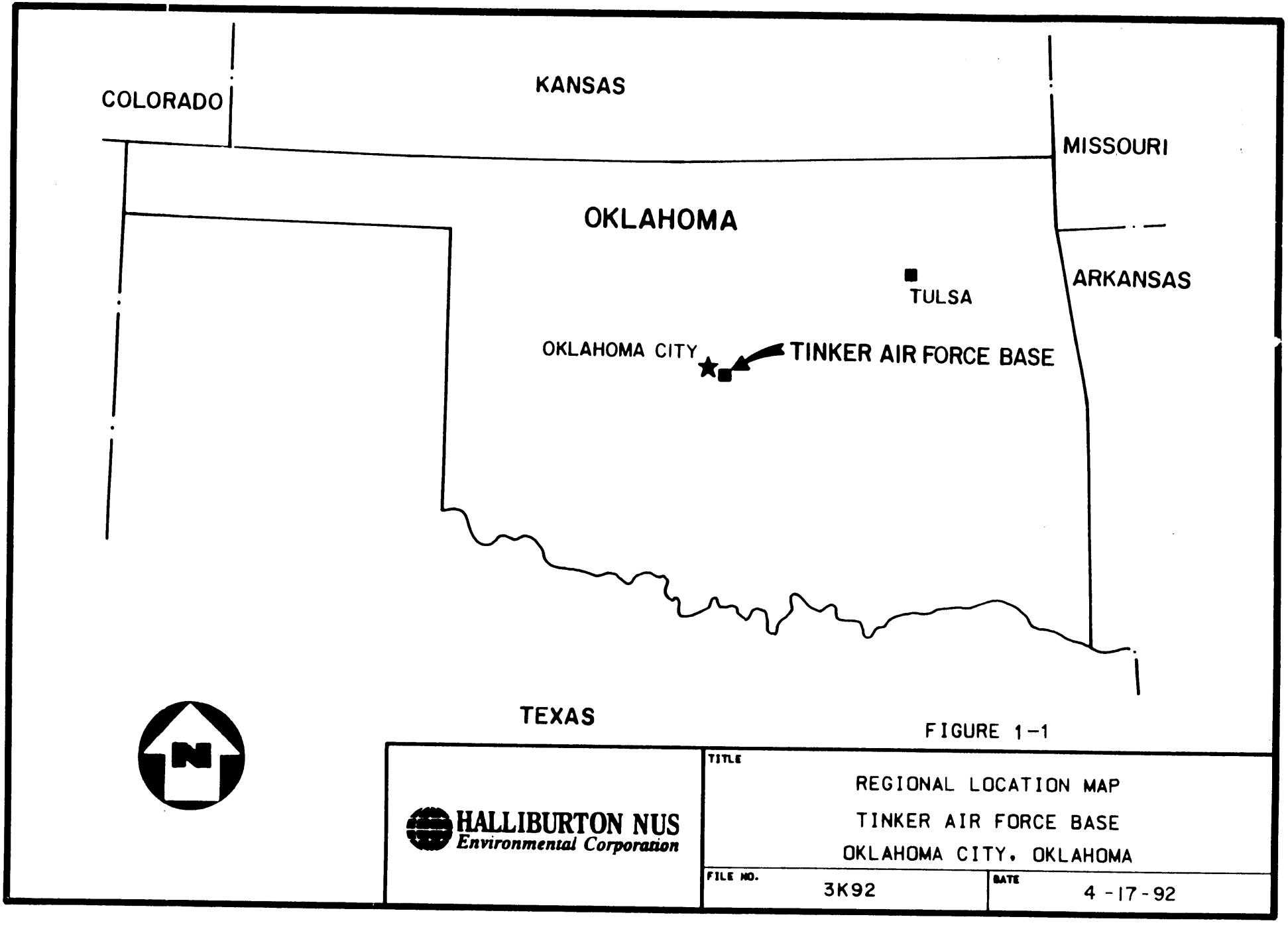


FIGURE 1-1

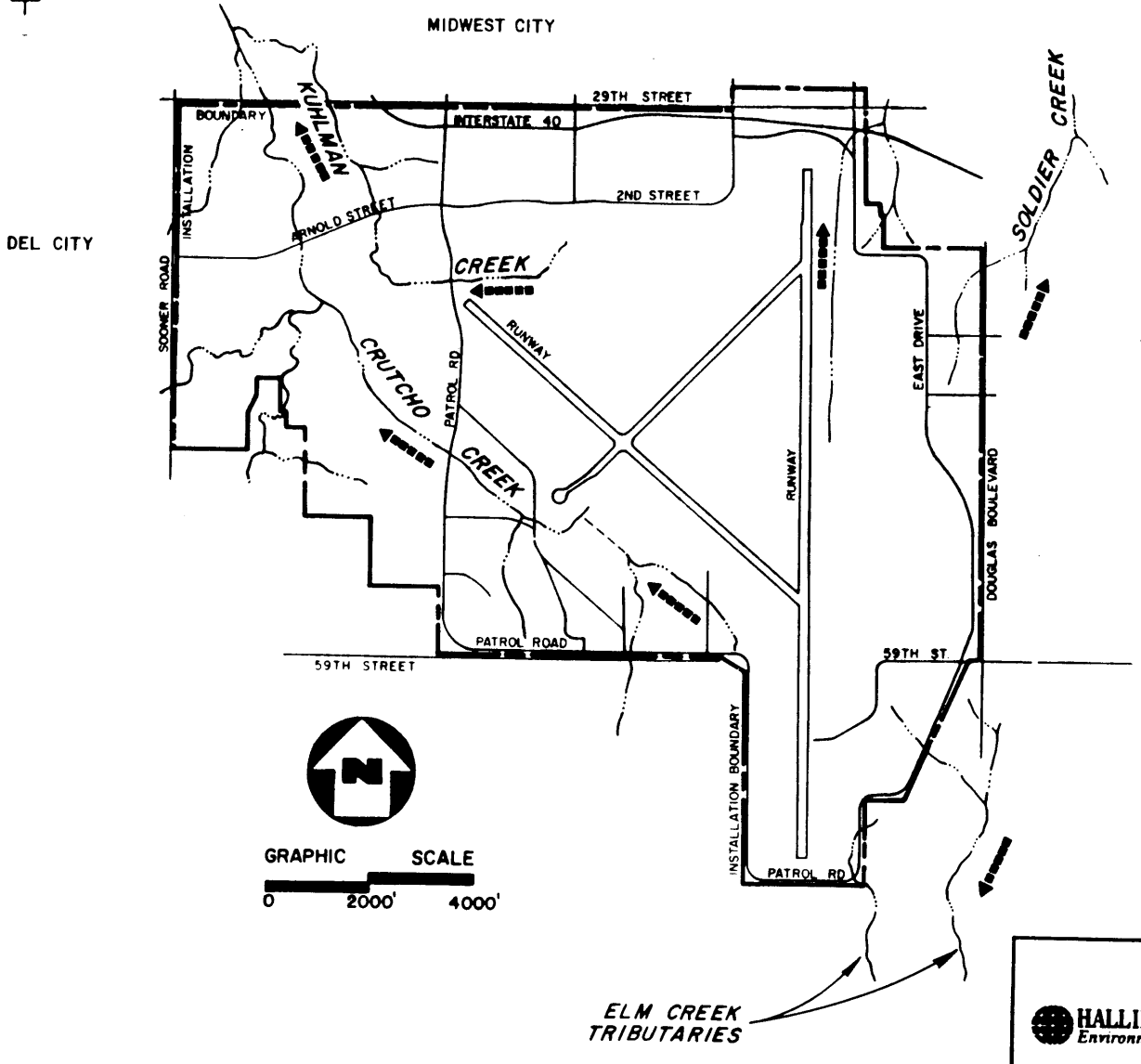
HALLIBURTON NUS Environmental Corporation

TITLE

REGIONAL LOCATION MAP
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

FILE NO. 3K92

DATE 4-17-92



LEGEND

CREEK

SURFACE DRAINAGE FLOW DIRECTION

FIGURE 1-2

HALLIBURTON NUS Environmental Corporation

TITLE: SITE MAP - CRUTCHO AND KUHLMAN CREEKS AND THE TRIBUTARIES OF ELM CREEK TINKER AIR FORCE BASE OKLAHOMA CITY, OKLAHOMA

FILE NO. 3K92

DATE 4-17-92

The 2854th Air Base Wing performs all administrative, security, maintenance, housekeeping, housing, fire protection, legal assistance, and logistical support for the base.

The Oklahoma City Air Logistics Center (OC-ALC) is the major organization at Tinker AFB. The mission of the OC-ALC is to provide logistic support to the operating commands of the USAF. The OC-ALC is the logistic support manager for the majority of the Strategic Air Command's bomber and tanker fleet, three air-launched missiles, a substantial portion of the jet engines in the Air Force inventory, and approximately 140,000 items in the hydraulic, pneumatics, and instrument areas. The center also supports a large industrial complex to overhaul, modify, and repair the aircraft engines and a vast number of accessory items.

As a major industrial complex, Tinker AFB generates, manages, and disposes of a variety of solid and hazardous wastes. Historically, much of this waste was treated by the AFB' s Wastewater Treatment Plant or disposed of in base landfills. In 1990, Tinker AFB submitted an application for a Part B Resource Conservation and Recovery Act (RCRA) permit in accordance with RCRA regulations. A permit was issued to Tinker AFB in 1991.

1.6 PREVIOUS STUDIES AND INVESTIGATIONS

Previous IRP studies performed at Tinker AFB have documented the releases of organic and inorganic contaminants to the environment. Building 3001 and Soldier Creek were placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priority List (NPL) and remedial designs have been initiated. RIs have been conducted at several base landfills, which confirmed leachate seeps and the release of contaminants to the groundwater and surface water. Since contaminant confirmation, Tinker AFB has taken corrective action to cap several landfills in accordance with RCRA guidelines.

An investigation of storm sewers discharging into Crutcho and Kuhlman Creeks was performed between October 1988 and June 1989. The analytical data from this study showed the presence of volatile organic compounds (VOC), oil and grease, chemical oxygen demand (COD), and methane blue active substances (MBAS) in storm sewer discharges to Crutcho and Kuhlman Creeks.

2.0 ENVIRONMENTAL SETTING

2.1 GEOGRAPHIC SETTING

Tinker AFB is situated within the Central Redbed Plains section of the Central Lowland Physiographic Province (Curtis and Ham 1972). This area is characterized by flat to gently rolling prairie and grassland, with well-entrenched main streams. Local relief is primarily the result of stream erosion. Surface elevations in the Oklahoma City area range from 1070 to 1400 feet (ft) above mean sea level (MSL). Ground surface elevations on the base range from 1190 to 1310 feet above MSL.

2.1.1 Surface Water Drainage

Primarily within the North Canadian River drainage basins, Tinker AFB lies between the North and South Canadian Rivers. Surface water drains by overland flow of runoff to several intermittent and ephemeral streams. Crutcho Creek, a tributary of the North Canadian River, drains the western and southern sections of the base, including the main instrument runway (Figure 2-1). Kuhlman Creek, a tributary of Crutcho Creek, drains the northern area of the base. The northeast portion of the base is drained by Soldier and West Soldier Creeks, which are not included in this study. The southeast area of the base is drained by tributaries of Elm Creek that are part of the South Canadian River drainage basin. Elm Creek flows into Stanley Draper Lake which is located approximately 1 mile southeast of the base boundary. Stanley Draper Lake is part of the Lake Thunderbird watershed. Lake Thunderbird is located approximately 12 miles southeast of the base.

2.1.2 Climate

The climate in central Oklahoma is characterized by long, hot summers and cold, windy winters. The mean annual temperature is approximately 61 degrees Fahrenheit with rainfall averaging about 32 inches per year. May is the wettest month due to strong spring thunderstorms. January is typically the driest month. Climatological data are presented in Table 2-1.

2.1.3 Land and Water Use

Tinker AFB is bordered on the north and west by the residential and commercial developments of Midwest City and Del City, respectively. Residential and agricultural areas exist east of the base. The General Motors vehicle assembly plant and undeveloped lands are situated south of the base.

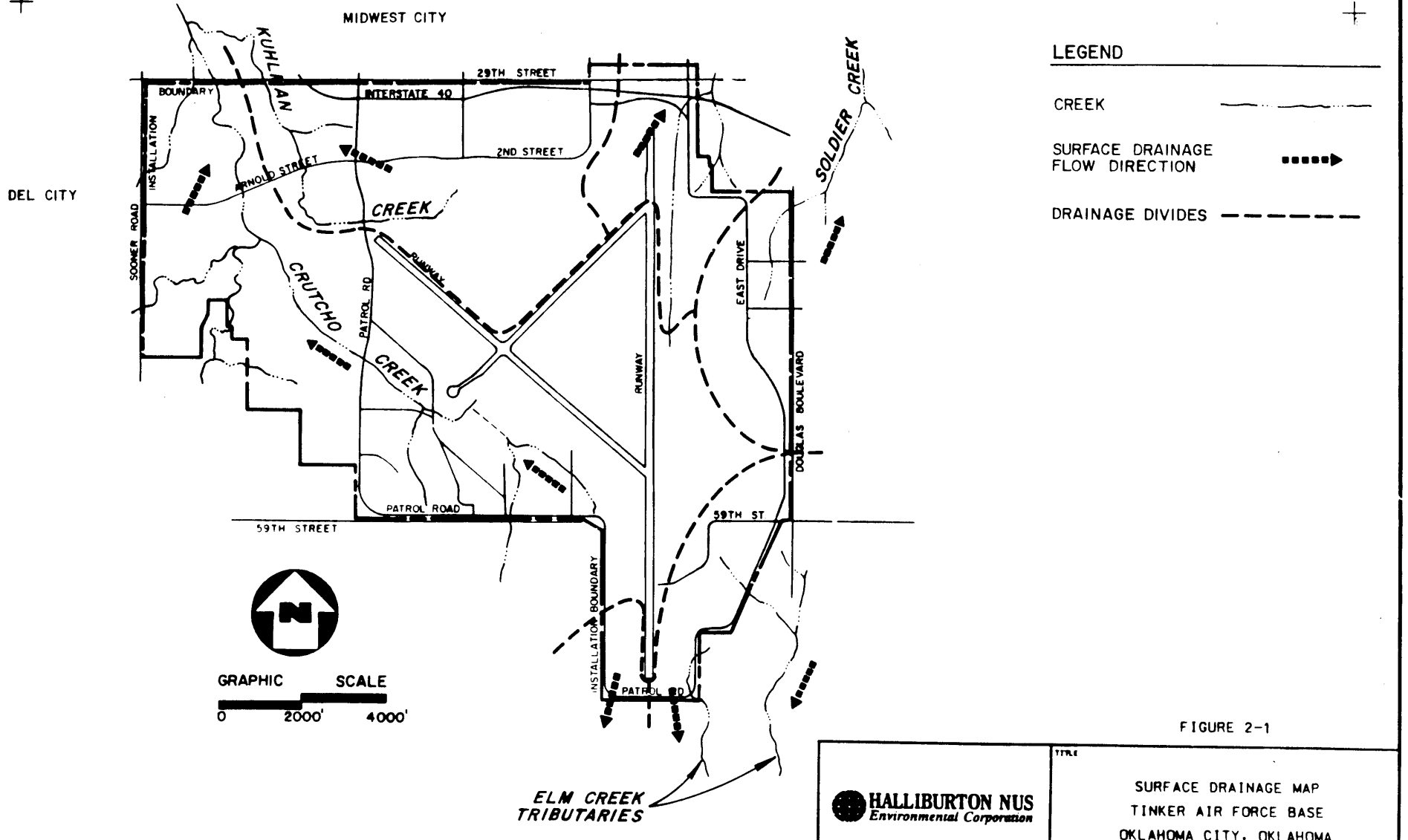


FIGURE 2-1

HALLIBURTON NUS
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TITLE
SURFACE DRAINAGE MAP
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

FILE NO. 3K92

DATE 4-17-92

TABLE 2-1

CLIMATOLOGICAL DATA
TINKER AIR FORCE BASE, OKLAHOMA

Month	Temperature (°F)					Precipitation (inches)				Snowfall (inches)			Surface Winds		
	Mean			Extreme		Monthly			Maximum 24 Hours	Monthly		Maximum 24 Hours	Prevailing Direction (16 PT)	Mean Speed (knots)	Maximum Speed[a] (knots)
	Daily		Monthly												
	Max	Min		Max	Min	Mean	Max	Min		Mean	Max				
January	46	27	37	80	-7	1.3	6.1	#	2.3	3	20	6	N	8	50
February	52	32	42	85	-1	1.3	3.6	#	2.0	2	13	7	S	9	58
March	60	39	50	91	-1	2.3	8.7	0.1	2.7	2	18	9	S	10	87[b]
April	71	51	61	98	25	3.1	8.7	0.7	3.0	#	1	1	S	10	65
May	78	59	69	98	35	6.1	12.0	0.3	5.7	0	0	0	S	8	78
June	87	68	77	106	51	4.1	11.2	0.4	4.1	0	0	0	S	8	72
July	92	72	82	107	53	3.3	8.2	#	4.5	0	0	0	S	7	70
August	92	71	81	107	56	2.3	9.3	#	3.8	0	0	0	S	7	62
September	84	64	74	107	39	3.3	11.9	#	6.2	0	0	0	S	7	62
October	74	53	64	98	26	2.9	13.5	#	6.0	#	#	#	S	8	54
November	60	40	50	84	11	1.9	7.3	0	3.4	1	6	5	S	9	54
December	50	31	41	85	0	1.4	3.5	#	2.3	2	11	6	S	9	54
Annual	70	51	61	107	-7	33.3	13.5	0	6.2	10	20	9	S	8	87[a]

Notes:

Period of Record: January 1943 - March 1984
#: trace amount.
(a) Instantaneous peak winds.
(b) Based on less than full month.

Source: Detachment 1, 17th Weather Squadron.
Date: June 1985

The groundwater and surface water within the state are classified according to their present and future beneficial uses by the Oklahoma Water Resource Board. Presently, groundwater from the Garber-Wellington Aquifer is used to provide the population of Oklahoma City and surrounding communities with the majority of their drinking water. However, Elm Creek is within the watershed of Lake Thunderbird, which is classified with a beneficial use as a public and private water supply. The beneficial uses for Crutcho and Kuhlman Creeks and the tributaries of Elm Creek as specified in the current Oklahoma Water Quality Standard (1989) and the proposed standards (1991) are as follows:

Crutcho and Kuhlman Creeks

- Habitat Limited Aquatic Community
- Agriculture
- Manufacturing and Industrial Process and Cooling Water
- Secondary Recreation
- Aesthetics

Tributaries of Elm Creek (Lake Thunderbird and Watershed, to include Stanley Draper Lake)

- Public and Private Water Supply*
- Warm Water Aquatic Community
- Agriculture (Class I irrigation)
- Primary Recreation
- Aesthetics

* Designated a sensitive public and private water supply.

2.2 GEOLOGIC SETTING

The Oklahoma City area is located in a tectonically stable area on the eastern flank of the Anadarko Basin. Bedrock units in the Oklahoma City area dip at a low angle to the west-southwest towards the center of the basin. No major faults or fault zones have been mapped under the basin. Figure 2-2 is a generalized geologic map of the Tinker AFB area from Wood and Burton (1968) and Radian (1984) showing that the base is underlain by Permian-aged sedimentary rocks of the lower Hennessey Group. The lowermost unit of the Hennessey Group is the Fairmont Shale, which is described by Bingham and Moore (1975) as a reddish-brown, blocky shale that exhibits a gradational contact with the underlying Garber Sandstone. Previous subsurface IRP investigations generally support this geologic interpretation. Most of the soil borings drilled on the base have penetrated the uppermost

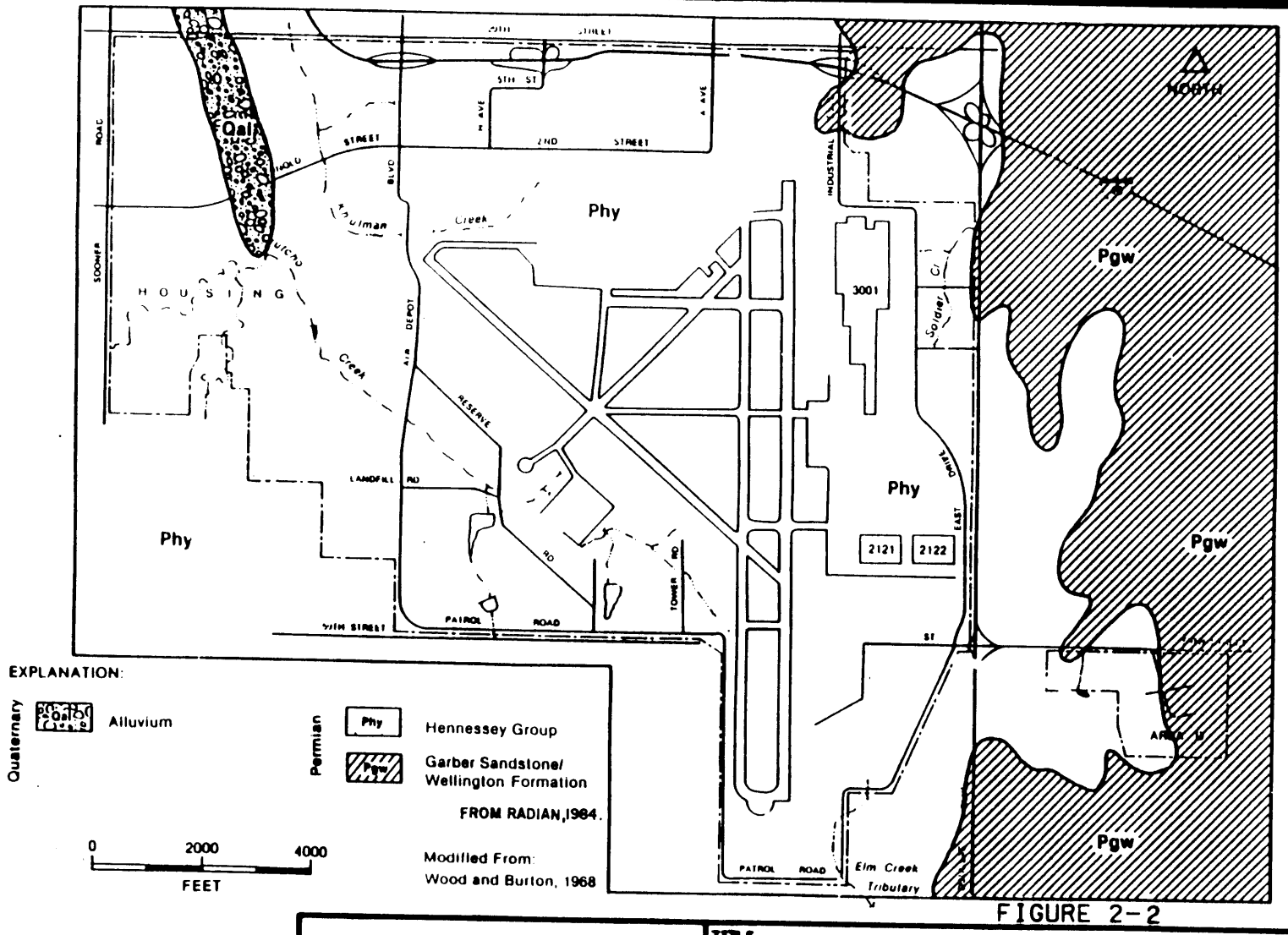

FIGURE 2-2

HALLIBURTON NUS
Environmental Corporation

TITLE

GEOLOGIC MAP
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

FILE NO.	DATE
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unit of weathered bedrock consisting of shale and silty shale. These units are believed to be the residuum of the lowermost units of the Hennessey Group. The only geologic units younger than the Hennessey Group shales are the recent-aged alluvial deposits present in the stream floodplains on the base.

2.3 HYDROGEOLOGIC SETTING

The groundwater hydrogeology of the Tinker AFB area has been described by Jacobsen and Reed (1949), Wood and Burton (1968), Bingham and Moore (1975), Bedinger and Sniegocke (1976), and Wickersham (1979). According to these reports and the findings of previous IRP investigations (Radian Corporation 1984a and USACOE 1988), two distinct aquifers exist beneath the base: (1) a shallow unconfined, perched aquifer and (2) a deeper regional aquifer. Contamination detected in both aquifers during previous IRP investigations indicate a hydraulic connection between these aquifers.

The shallow perched aquifer was encountered in soil borings drilled on the base by the U.S. Army Corps of Engineers (USACOE) and HALLIBURTON NUS. Depth to groundwater ranges between 10 and 20 ft below ground surface. Groundwater in this shallow aquifer flows through weathered silts and clays of the Hennessey Group.

A deep confined unit known as the Garber-Wellington Aquifer provides drinking water for over 500,000 residents of Oklahoma City. Beneath Tinker AFB, the Garber-Wellington Aquifer is encountered at an approximate depth of 50-80 ft and continues vertically for approximately 900 ft in the Tinker AFB area. It consists of lenticular and interbedded sandstone, shale, and siltstone. The regional flow of groundwater in this confined aquifer is to the southwest. The recharging zone for this aquifer encompasses the eastern half of Oklahoma County, including Tinker AFB.

3.0 INVESTIGATION PROCEDURES AND ACTIVITIES

As stated in Section 1.6, previous IRP studies have confirmed soil and/or groundwater contamination at base landfills, fuel storage areas, and storm sewers, which drain into Crutcho and Kuhlman Creeks and the tributaries of Elm Creek. However, these investigations did not include assessment of the surface water and sediments in these creeks. This RI was initiated to identify and characterize surface water and sediment contamination, if present, in the creeks within and contiguous to Tinker AFB. The activities and procedures used in this investigation are described in the following sections.

3.1 FIELD ACTIVITIES AND PROCEDURES

Field investigation activities performed at the base included multi-phase surface water and sediment sampling, stream flow measurements, and verification of storm sewer outfall locations. A general overview of the field investigation activities conducted and the procedures used are discussed in the following subsections. Field work was conducted in accordance with the approved Work Plan (HALLIBURTON NUS 1992).

3.1.1 Surface Water And Sediment Sampling

The surface water and sediment sampling was conducted to generate sufficient data to characterize the nature and extent of the contaminants, if present, in Crutcho and Kuhlman Creeks and tributaries of Elm Creek. Sampling was performed in two stages: baseline and confirmation data collection. Baseline sampling activities were initially conducted in July 1991 and again in October 1991 to determine if contamination was present. The resulting analytical data were used to identify areas of the creeks where additional sampling was needed to define the nature and extent of contamination, if present. Confirmation sampling was performed in February 1992 and additional confirmation sampling was performed in May 1992. Confirmation data collection activities were scheduled to monitor possible seasonal variations in contaminant release.

During the baseline and confirmation field efforts, surface water and sediment samples were collected in a downstream-to-upstream progression to minimize the potential for cross-contamination. Surface water samples were collected first to avoid turbid, sediment-laden water. During the July 1991 baseline field activities, low water levels in each stream would not allow direct sampling with the specified laboratory container. Instead, a clean, dedicated plastic sample bottle, provided by the HALLIBURTON NUS laboratory, was used to collect and then transfer each surface water sample to its appropriate laboratory container. Each sample-transfer bottle was

disposed of following sample collection. In February and May 1992, the confirmation surface water samples were collected by using the direct sampling method.

After surface water samples were collected from each location, a composite sediment sample was collected along an imaginary line perpendicular to the stream flow direction. Beginning on one bank of the stream, field technicians progressed across the stream toward the opposite bank, collecting a composite sediment sample. During the July 1991 effort, sediment samples were directly sampled by using the sample container to collect the sediment sample. In February 1992, a decontaminated stainless steel bowl and trowel were used to collect the sediment sample which was then transferred to the appropriate, laboratory-provided jars. Decontamination procedures are described in Subsection 3.1.1.4. No sediment samples were collected in October 1991 or in May 1992.

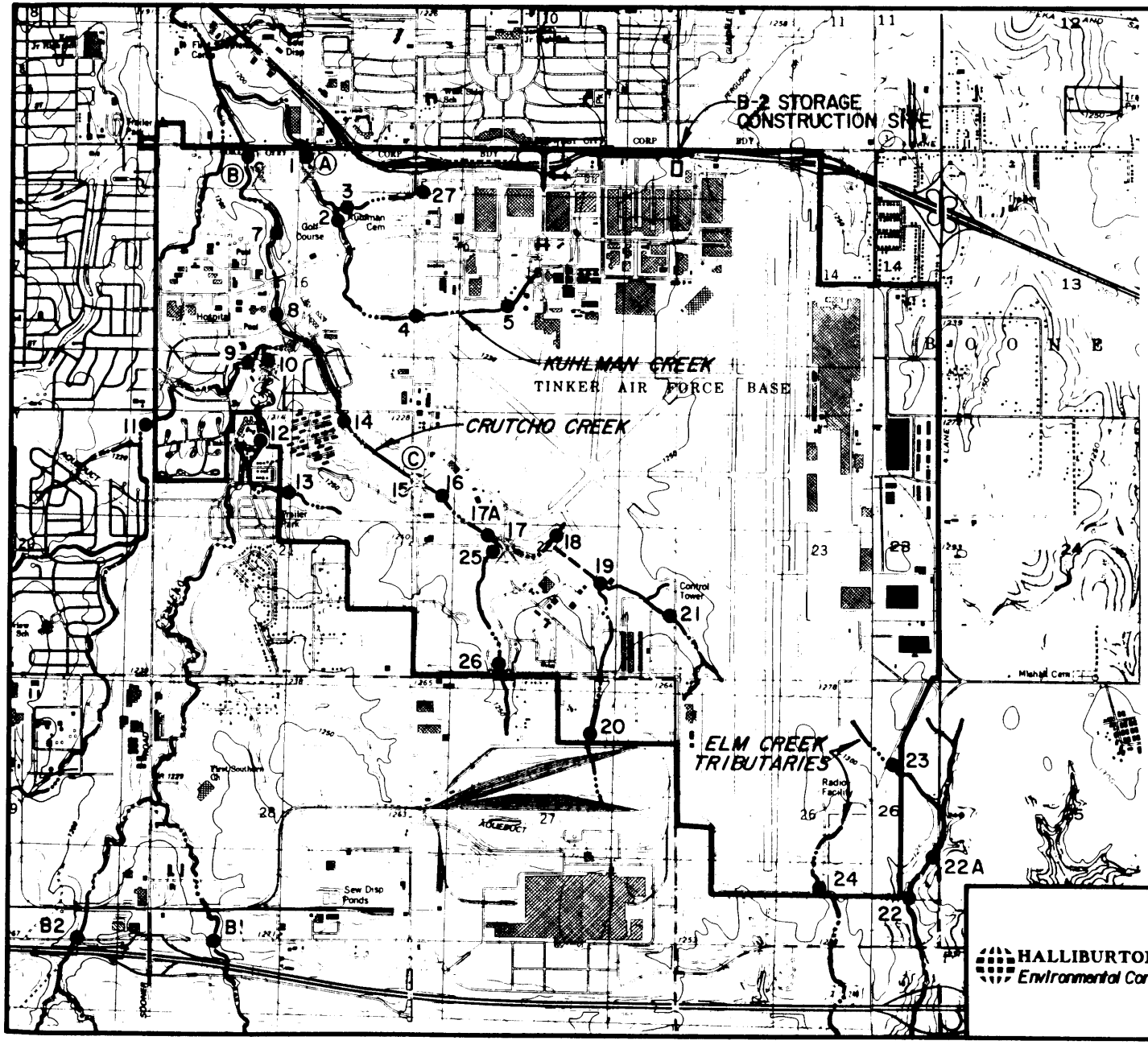
Immediately after collection, each sample was assigned a specific sample identification number. The method for sample identification number assignment is described in Subsection 3.1.1.3. This number was recorded on the sample container label, in the field log book, and on the shipping chain-of-custody forms. Sample containers were then placed on ice in insulated coolers for temporary storage prior to shipment to the analytical laboratory.

During the baseline field effort, wooden stakes were marked with the appropriate sample location number and placed at each location. This procedure allowed field technicians to collect confirmation samples from approximately the same location as baseline samples.

3.1.1.1 Baseline Data Collection

On July 4–8, 1991, HALLIBURTON NUS field technicians collected baseline samples at sample locations 1 through 26 as shown in Figure 3-1. Surface water samples were also collected from 20 locations (1 through 12, 14 through 22, and 26). Due to dry creek conditions, surface water samples could not be obtained at Locations 13, 23, 24, and 25. Sample locations were selected to provide baseline analytical data at the following areas:

- At the base boundaries, to document the migration of contaminants entering or leaving the base.
- Downstream of potential contaminant sources, such as landfills, fuel depots, and major storm sewer outfalls, to quantify the contaminant contribution from these sources.
- Upstream of major stream intersections, to define the contaminant load in each tributary.



LEGEND

INSTALLATION BOUNDARY

CREEK

SAMPLE LOCATION 10

FLOW MEASUREMENT LOCATION (A)

NOTE:

BASE MAP TAKEN FROM MIDWEST CITY (1986 EDITION) AND CHOCTAW, OKLAHOMA (1975 EDITION) U.S.G.S. 7.5' TOPOGRAPHIC QUADRANGLES.

GRAPHIC SCALE

0 2000' 4000'

N

FIGURE 3-1

HALLIBURTON NUS Environmental Corporation

TITLE

SAMPLE LOCATION MAP

TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

DRAWING NO. 3K92G001

DATE 4-17-92

- At stream reach intervals of approximately 1000 ft., to detect unsuspected sources and provide spatial estimates of the extent of contamination.

A total of 26 sediment samples and 22 surface water samples were collected during the July 1991 baseline field effort. These samples were analyzed for inorganics,VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and contaminant indicators (CIs). Contaminant indicator analyte lists for both surface water and sediment are presented in Appendix A. Tables 3-1 and 3-2 show the analyses performed on each sample at each sample location. These analytical parameters were selected based on the results of previous environmental studies at Tinker AFB or are RCRA Facility Investigation (RFI) contaminant indicators. The selection of analytical parameters performed for each sample location is as follows:

- Sediment samples taken at base boundaries, at intersections of major stream tributaries, and downstream of major potential contamination sources were analyzed for 26 inorganics, SVOCs, pesticides/PCBs, cyanide, and CIs.

- Sediment samples taken at other locations were analyzed for 16 inorganics and CIs. Samples from Locations 16 and 25 were also sampled for radioactivity.

- Surface water samples taken at base boundaries and downstream of major potential contaminant sources were analyzed for 19 inorganics, CIs, and part or all of the following parameters: VOCs, SVOCs, pesticides/PCBs, and cyanide.

- Surface water samples taken at other locations were analyzed for 19 inorganics and CIs.

On October 26–28, 1991, base personnel collected surface water samples from Locations 13, 23, 24, 25, and 27. As previously stated, these locations were dry in July 1991. The analytical parameters included inorganics and CIs and are listed in Table 3-2.

3.1.1.2 Confirmation Data Collection

Field confirmation activities were conducted in February and May 1992. The objectives of confirmation activities were to (1) monitor seasonal variation in contaminant release, (2) more clearly define the nature and extent of contamination, and (3) if possible, identify contaminant sources. The baseline data were used to select confirmation sampling points. All confirmation samples were collected by following the procedures described in Section 3.1.1.

TABLE 3-1

BASELINE SEDIMENT ANALYSES[a] July, 1991
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sample No. [b]	ANALYSES						
	Contaminant Indicators List 1	Contaminant Indicators List 1A	Inorganics	Pesticides/ PCBs	Semivolatile Organics	Cyanide	Radioactivity (Gross Alpha and Beta)
SD01	X		X	X	X	X	
SD02		X	X				
SD03		X	X				
SD04		X	X				
SD05		X	X				
SD06	X		X	X	X	X	
SD07		X	X				
SD08		X	X				
SD09		X	X				
SD10		X	X				
SD11	X		X	X	X	X	
SD12		X	X				
SD13		X	X				
SD14		X	X				
SD15		X	X				
SD16	X		X	X	X	X	X
SD17		X	X				
SD18		X	X				
SD19		X	X				
SD20	X		X	X	X		
SD21		X	X	X			
SD22	X		X			X	
SD23		X	X				
SD24		X	X				
SD25		X	X				X
SD26		X	X				
TOTALS	**6**	**20**	**26**	**6**	**5**	**5**	**2**

(a) Sediment samples collected on July 4–8, 1991.

(b) The last two digits of the sample number designate the sample location as shown in Figure 3-1 .

TABLE 2

BASELINE SURFACE WATER ANALYSES - JULY AND OCTOBER 1991 (a)
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sample No. (b)	ANALYSES							
	Contaminant Indicators	Volatile Organics	Pesticides/PCBs	Semivolatile Organics	Inorganics	Cyanide	Nitrogen	TOX and Phenols(c)
SW01	X	X	X	X	X	X	X	
SW02	X				X		X	X
SW03	X				X		X	X
SW04	X				X		X	X
SW05	X	X		X	X		X	
SW06	X	X	X	X	X	X	X	
SW07	X				X		X	X
SW08	X				X		X	X
SW09	X				X		X	X
SW10	X				X		X	X
SW11	X	X		X	X		X	
SW12	X				X		X	X
SW13(d)	X				X			
SW14	X				X		X	X
SW15	X				X		X	X
SW16	X	X	X	X	X	X	X	
SW17	X				X		X	X
SW18	X				X		X	X
SW19	X				X		X	X
SW20	X				X		X	X
SW21	X			X	X		X	
SW22	X		X		X		X	X
SW23(d)	X				X			
SW24(d)	X				X			
SW25(d)	X				X			
SW26					X			
SW27(d)	X				X			
TOTALS	**26**	**5**	**4**	**6**	**27**	**3**	**21**	**15**

(a) Samples collected on October 26–28, 1991. Remaining samples collected on July 4–8, 1991.
(b) The last two digits of the sample number designate the sample location as shown in Figure 3-1 .
(c) TOX - Total Organic Halogens.

On February 3–10, 1992, a total of 11 sediment and 11 surface water samples were collected by HALLIBURTON NUS. Seven of the 11 sample locations had been previously sampled during the July 1991 baseline activities. At two locations, B1 and B2, situated upgradient of Tinker AFB on Crutcho Creek, sediment and surface water samples were collected to establish background conditions. Sediment samples were also collected from five locations for grain size analyses. Tables 3-3 and 3-4 show the analyses performed at each location sampled. The locations sampled are shown in Figure 3-1. The February 1992 laboratory results are included in Appendix E.

Several surface water and sediment analytes included in baseline analyses were not included as part of confirmation analyses. Eight naturally occurring inorganics and strontium, which was not detected in any of the baseline samples, were not included in the sediment inorganic analyte list. Calcium, magnesium, and sodium were not included in the surface water inorganic analyte list. Several miscellaneous analytes such as phosphorus, sulfate, nitrite phenolics, chloride, fluoride, and specific conductance were also removed from the sediment or surface water CI analyte lists. Additional analytes with numerical criteria in the Oklahoma Water Quality Standard were added to the surface water CI and pesticide/PCBs analyte lists. Fluoride, hardness, and methane blue active substances were added to the CI analyte list and seven organophosphorous pesticides were added to the pesticide/PCBs analyte list. Other sediment and surface water analyte lists are identical to baseline sample analyte lists.

On May 4–9, 1992, surface water samples were collected by HALLIBURTON NUS from seven creek locations. No sediment samples were collected. The surface water samples were collected at Locations 1 and 5 on Kuhlman Creek, Locations 6, 11, 15, and 20 on Crutcho Creek, and Location 22A on Elm Creek. Each location had been previously sampled during the July 1991 baseline activities and the February 1992 confirmation activities.

Five of the seven samples were analyzed for VOCs and SVOCs. Four samples were analyzed for 16 inorganics, pesticides, and PCBs. Analyses for cyanide, MBAS, and radioactivity were performed on one sample from each of the three creeks. Table 3-5 shows the analyses performed on each sample location.

3.1.1.3 Sample Identification

Each sediment and surface water sample collected for laboratory analyses during the RI was assigned a 12-digit alphanumeric code (i.e., sample identification number). This code was used to track the sample from collection, through laboratory analyses, and into the final RI report. Each code

TABLE 3-3

CONFIRMATION SEDIMENT ANALYSES - FEBRUARY 1992 (a)
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sample No. (b)	ANALYSES						
	Contaminant Indicators	Inorganics	Pesticides/ PCBs	Semivolatile Organics	Cyanide	Radioactivity (Gross Alpha and Beta)	Grain Size
SD01	X	X	X	X	X		
SD03	X						
SD05	X	X		X			
SD06	X	X	X	X	X		X
SD11	X						
SD15	X	X	X	X		X	X
SD17A	X					X	
SD22A	X	X	X	X	X	X	
SD24	X	X					X
SDB1	X	X	X	X	X	X	X
SDB2	X	X	X	X	X	X	X
TOTALS	**11**	**8**	**6**	**7**	**5**	**5**	**5**

(a) Samples collected on February 3–10, 1992.
(b) The last two digits of the sample number designate the sample location as shown in Figure 3-1.

TABLE 3-4

CONFIRMATION SURFACE WATER ANALYSES - FEBRUARY 1992 (a)
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sample No. (b)	ANALYSES							Radioactivity (Gross Alpha and Beta)
	Contaminant Indicators	Volatile Organics	Pesticides/PCBs	Semivolatile Organics	Inorganics	Cyanide	MBAS(c)	
SW01	X	X	X	X	X	X	X	X
SW05	X	X		X	X			
SW06	X	X	X	X	X	X	X	X
SW11	X							
SW15	X	X	X	X	X			X
SW17A	X							
SW20	X				X			
SW22A	X	X	X	X	X	X	X	X
SW24	X	X	X	X	X	X		
SWB1	X	X	X	X	X	X	X	X
SWB2	X	X	X	X	X	X	X	X
TOTALS	**11**	**8**	**7**	**8**	**9**	**6**	**5**	**6**

(a) Samples collected on Febraury 3–10, 1992.
(b) The last two digits of the sample number designate the sample location as shown in Figure 3-1.
(c) Methane blue active substances.

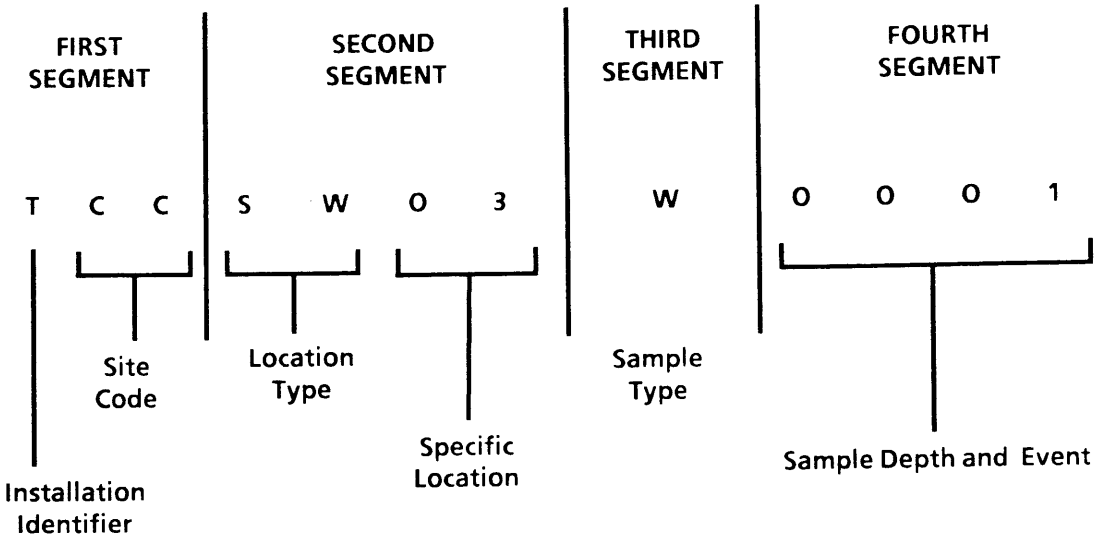
TABLE 3-5

CONFIRMATION SURFACE WATER ANALYSES - MAY 1992 [a]
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sample No. [b]	ANALYSES							
	Contaminant Indicators	Volatile Organics	Pesticides/PCBs	Semivolatiles Organics	Inorganics	Cyanide	MBAS[c]	Radioactivity (Gross Alpha and Beta)
SW01	X	X	X	X	X	X	X	X
SW05	X	X		X				
SW06	X	X	X	X	X	X	X	X
SW11	X							
SW15	X	X	X	X	X			
SW20	X							
SW22	X	X	X	X	X	X	X	X
TOTALS	**7**	**5**	**4**	**5**	**4**	**3**	**3**	**3**

(a) Samples collected on May 5–9, 1992.
(b) The last two digits of the sample number designate the sample location as shown in Figure 3-1.
(c) Methane blue active substances.

identified the installation (i.e., Tinker AFB), the collection site (i.e., the specific creek), the specific sample location and sample type. An example of the identification code follows:



The letter "T" will be used exclusively as the Installation Identifier in all samples. To designate the collection site for the site code, the creek names were abbreviated as follows:

Crutcho Creek = CC
Kuhlman Creek = KC
Elm Creek = EC

For the sample location type, the following identifiers were used:

Sediment Sample = SD
Surface Water = SW

Sample type (i.e., matrix) identifiers are as follows:

Sediment = E
Duplicate Sediment = F
Surface Water = W
Duplicate Water = C

For surface water and sediment samples, the first two digits in the fourth segment shown were numbered "00" to signify that the sample depths were collected from the surface.

To differentiate between sampling events, the last two digits in the identification code were used to designate the specific sampling round. In other words, identification codes for baseline samples collected in July 1991 and October 1991 ended in "01" for surface water samples and "00" for sediment samples. All confirmation sample codes ended in "02" for the February 1992 field event and "03" for the May 1992 field event.

Duplicate samples collected for fixed base laboratory use were coded with "Y," "X," "Q," and "Z" sample type qualifiers instead of the "E," "F," "W," and "C" sample type qualifiers. The last five digits (segments three and four) of the quality control blank sample numbers represent the sampling date. QA blank samples were identified as follows:

Rinsate Blank = RB
Field Blank = FB
Trip Blank = TB

3.1.1.4 Decontamination Procedures

All stainless steel spoons and bowls used to collect sediment samples were decontaminated prior to use. The following decontamination procedures were used throughout the investigation:

- Wash with a mixture of Alconox and HPLC grade analyte-free water.
- Rinse with ASTM Type II or HPLC water.
- Rinse with methanol (pesticide-grade).
- Rinse with hexane.
- Rinse with methanol.
- Rinse with ASTM Type II or HPLC water.
- Air dry and wrap in aluminum foil.

New, clean, and disposable surgical gloves were worn by the field technician each time a sediment or surface water sample was collected as well as during equipment decontamination.

3.1.2 Stream Characteristics

Field measurements for ph, specific conductivity, temperature, and dissolved oxygen were made during baseline and confirmation field activities and prior to surface water sample collection. The field measurement instruments used to measure these parameters were calibrated daily in accordance with the manufacturers' recommended procedures by using calibration standards. Field measurements and calibration results were recorded in the field log book. Field measurement results are presented in Tables 3-6 , 3-7, and 3-8.

The field measurements varied spatially between sampling locations and temporally between sampling events. These variations were expected given the stream's low flow (ephemeral nature) and the quantity of process waters discharged into them. Surface water temperatures ranged from 34.6 to 22.4 degrees Celsius (°C) in July 1991, from 12.8 to 5.6°C in February 1992, and from 25.9 to 14.6°C in May 1992. The average surface water temperatures for these sampling events are 26.6°C, 10.2°C and 20.6°C, respectively. Dissolved oxygen concentrations varied from 11.8 to 2.2 mg/l in July 1991, from 19.0 to 9.5 mg/l in February 1992, and from 15.3 to 10.0 mg/l in May 1992. The average dissolved oxygen concentration for these sampling events are 7.2 mg/l, 13.4 mg/l, and 12.2 mg/l, respectively. Specific conductivity varied from 1300 to 225 micromhos/cm in July 1991, from 3010 to 650 micromhos/cm in February 1992, and from 1800 to 540 micromhos/cm in May 1992. The average specific conductivity values for these sampling events are 668 micromhos/cm, 1238 micromhos/cm, and 971 micromhos/cm, respectively. The range of pH values in July 1991 was 8.38 to 6.04, 8.34 to 7.78 in February 1992, and 8.26 to 4.19 in May 1992. The three low pH values (4.19, 4.30, and 4.55) recorded on May 8, 1992, are not thought to reflect stream conditions. A pH meter malfunction is suspected since all measurements taken on May 8 were low. The average pH values for these sampling events are 6.69, 8.12, and 6.38 respectively.

3.1.3 Stream Flow Measurements

Stream flow measurements were made at two locations on Crutcho Creek and one location on Kuhlman Creek during the July 1991, February 1992, and May 1992 sampling events. No flow measurements were made on Elm Creek due to the ephemeral nature of the stream. Stream flow measurement locations "A," "B," and "C" are shown in Figure 3-1.

TABLE 3-6

FIELD STREAM MEASUREMENTS
JULY 1991
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample No.(a)	Dissolved Oxygen (mg/l)	pH	Temperature (°C)	Specific Conductivity (micromhos/cm)
SW01	6.4	6.38	27.7	460
SW02	6.6	6.50	29.6	400
SW03	9.4	6.49	33.0	760
SW04	6.6	8.35	25.8	520
SW05	9.6	8.38	24.3	710
SW06	6.6	6.22	26.3	540
SW07	7.0	6.85	28.0	570
SW08	5.1	6.04	23.2	690
SW09	7.0	6.10	24.3	780
SW10	7.0	6.10	24.3	710
SW11	5.6	6.25	24.0	680
SW12	8.4	6.19	24.8	700
SW13(b)				
SW14	6.5	6.09	24.6	440
SW15	9.0	6.38	27.8	780
SW16	7.6	6.44	27.7	910
SW17	11.8	6.74	34.6	810
SW18	2.2	6.69	26.2	680
SW19	6.6	7.37	27.7	680
SW20	6.6	6.78	22.6	1300
SW21	9.8	6.81	30.6	680
SW22	5.6	7.35	22.4	225
SW23(b)				
SW24(b)				
SW25(b)				
SW26	NS	NS	NS	NS
AVERAGE	7.2	6.69	26.6	668

(a) - The last two digits of the sample number designate the sample locations as shown in Figure 3-1.
(b) - No surface water samples were taken at these locations during this sampling event.
NS - Not Measured

TABLE 3-7

FIELD STREAM MEASUREMENTS
FEBRUARY 1992
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample No.(a)	Dissolved Oxygen (mg/l)	pH	Temperature (°C)	Specific Conductivity (micromhos/cm)
SW01	19.0	8.17	12.8	760
SW05	9.5	7.96	12.0	1740
SW06	10.5	7.90	9.7	1000
SW11	14.5	8.12	11.7	1000
SW15	14.0	7.78	9.4	700
SW17A	(b)	8.25	12.1	660
SW20	15.0	8.34	10.4	1,700
SW22A	11.0	8.22	5.6	650
SW24	13.5	8.28	10.8	1,200
SWB1	(b)	8.22	9.2	1,200
SWB2	14.5	8.07	8.0	3,010
AVERAGE	13.4	8.12	10.2	1,238

(a) - The last two digits of the sample number designate the sample locations as shown in Figure 3-1.
(b) - Reading not recorded.

TABLE 3-8

FIELD STREAM MEASUREMENTS
MAY 1992
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample No.(a)	Dissolved Oxygen (mg/l)	pH	Temperature (°C)	Specific Conductivity (micromhos/cm)
SW01	15.3	8.26	19.4	960
SW05	13.2	4.30	22.9	700
SW06	12.0	8.04	22.3	1300
SW11	10.5	7.55	19.6	900
SW15	14.0	4.19	25.9	600
SW20	10.0	7.79	14.6	1800
SW22A	10.4	4.55	19.4	540
AVERAGE	12.2	6.38	20.6	971

(a) - The last two digits of the sample number designate the sample locations as shown in Figure 3-1.

Stream flow measurements were made on Kuhlman Creek (Location "A" in Figure 3-1) using an existing 90 degree V-notch weir. The weir consists of a low concrete dam with a 6- ft - wide steel weir plate installed in the concrete wall as shown in Figure 3-2. The weir plate leans slightly downstream and is not quite level but is generally in fair condition. The following procedure was used to measure stream flow using the V-notch weir:

- Sediment and debris were removed from the creek bottom upstream of the weir to a depth of approximately 6 inches below the bottom of the V-notch opening.

- The top of the V-notch weir plate was leveled, if possible. The top of the existing weir plate at location "A" could not be leveled.

- A metal rod or wooden stake was driven into the stream bed upstream of the weir to measure the head on the weir. This rod or stake was installed upstream at a distance of at least two times the depth of the water flowing through the weir so as to minimize drawdown effects. The top of the rod was installed level (by using a carpenter's level) with the top of the weir plate. If the weir was not level, a rod was installed on both sides of the weir so that the average stream flow level could be calculated.

- The head on the weir was determined by measuring the distance from the top of the rod to the water surface and subtracting this value from the total depth of the weir notch.

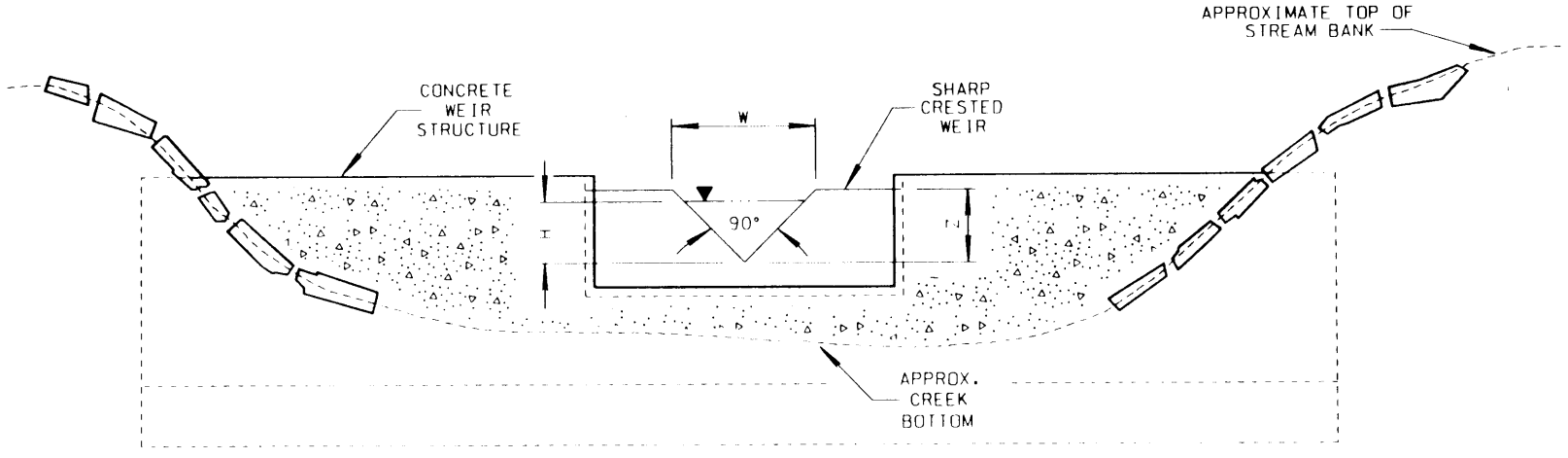
- Stream flow was then calculated using the following general weir flow equation for a 90 degree V-notch weir:

$$Q = CH^{5/2}$$

where

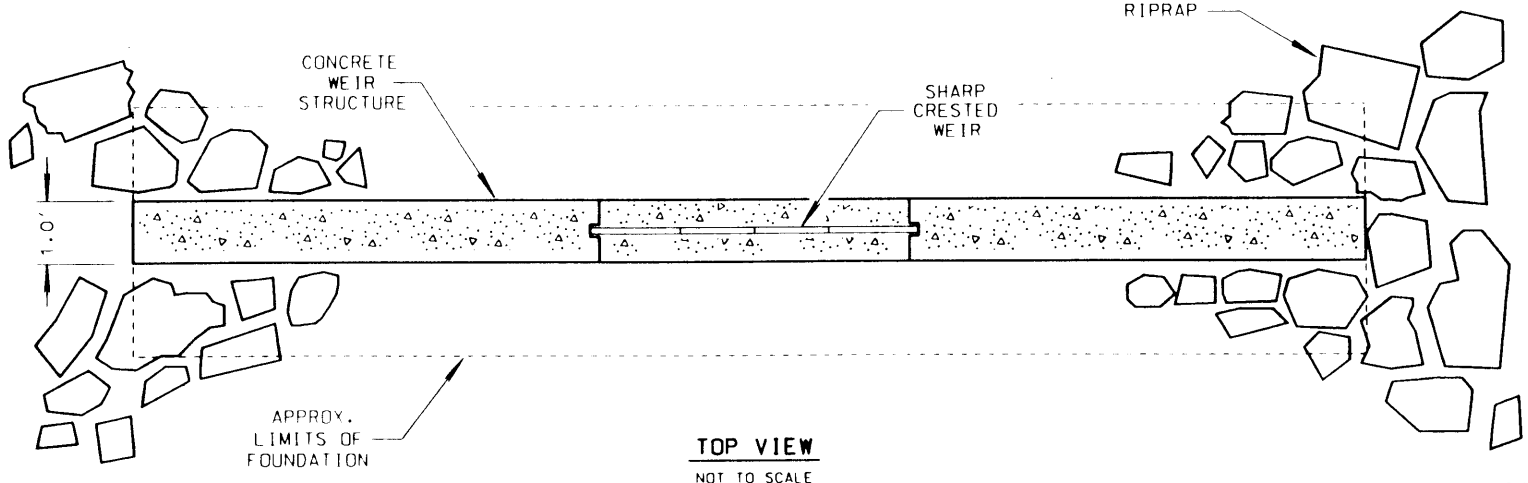
Q = Stream flow in cubic feet per second(cfs)
C = Coefficient of discharge
H = Static head (ft)

The flow at Location "A" was calculated to be 0.22 cfs [99 gallons per minute (gpm)] in July 1991, 0.34 cfs (153 gpm) in February 1992, and 0.22 cfs (100 gpm) in May 1992. Stream flow calculations are included in Appendix B.



PROFILE VIEW

NOT TO SCALE



TOP VIEW

NOT TO SCALE

LOCATION	W (FT.)	Z (FT.)	H (FT.) 7-91	H (FT.) 2-92	H (FT.) 5-92
KUHLMAN CREEK "A"	2.33	1.17	0.36	0.45	0.38
CRUTCHO CREEK "C"	2.00	1.00	NM	0.30	0.15

NM = NOT MEASURED

FIGURE 3-2

HALLIBURTON NUS Environmental Corporation

TITLE

V-NOTCH WEIR DETAILS

TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

DRAWING NO. 3K92C0004

DATE 8 21 92

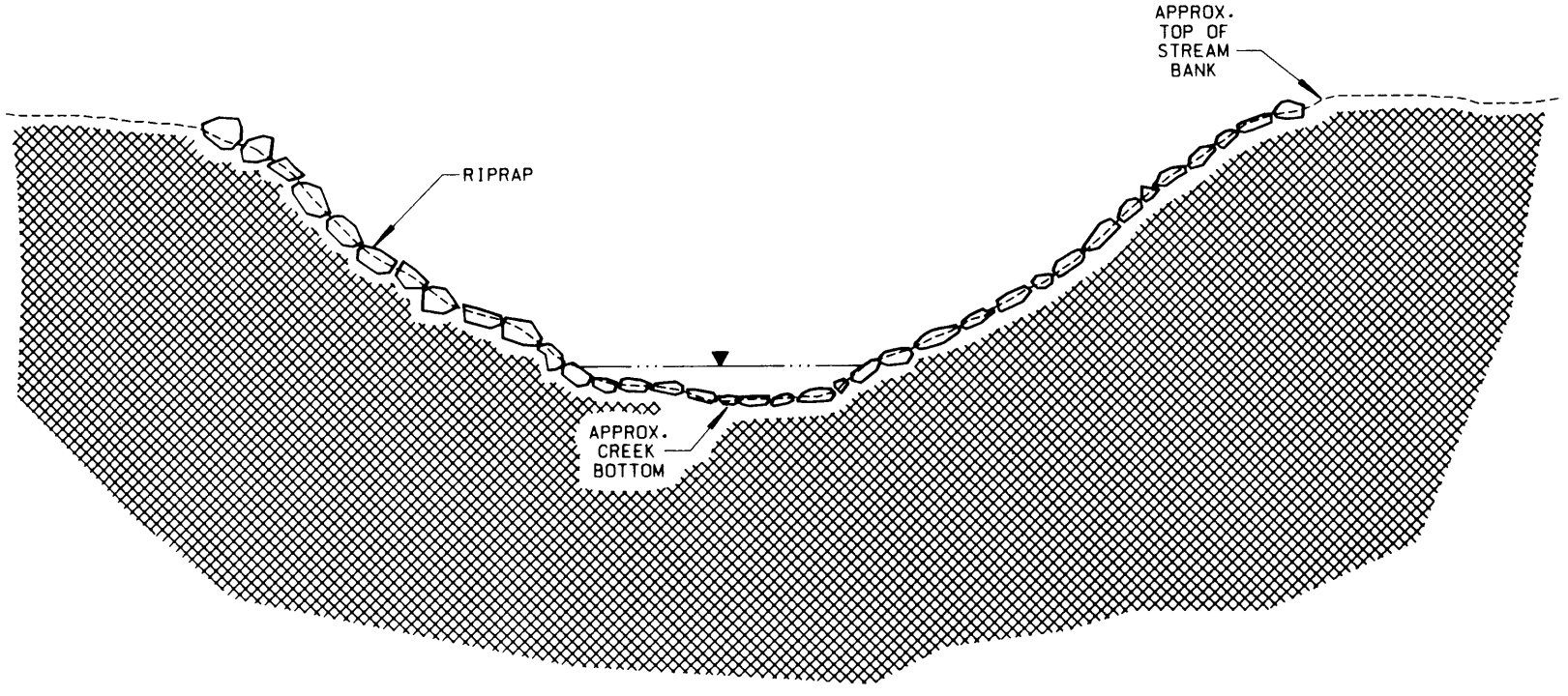
Stream flow measurements were made at Location "B" (Figure 3-1) on Crutcho Creek by using floats in July 1991 and by using a current meter in February 1992 and May 1992. The July 1991 flow measurement was calculated by measuring the time required for several floats to travel a known distance between two stream sections. This information was then used to calculate the surface velocity (distance between the two sections divided by the average travel time of the floats). A coefficient of 0.85 (USGS 1984) was used to convert surface velocity to mean stream velocity. Stream flow was determined by multiplying mean stream velocity by the average cross-sectional areas at the two sections.

In February and May 1992, a Marsh-McBirney, Inc. Flo-Mate 2000 current meter was used to measure the flow in accordance with the current meter procedures described in Discharge Measurements at Gaging Stations (USGS 1984). The selected stream section (Figure 3-3) was surveyed and divided into 13 partial sections. The water depth and velocity were measured at each partial section using the current meter and associated wading rod. The velocities measured for each partial section were multiplied by the flow area of that section to determine the discharge per partial section. The total stream flow is the summation of the partial section flows.

The flow at Location "B" was calculated to be 0.42 cfs (189 gpm) in July 1991, 0.76 cfs (341 gpm) in February 1992, and 0.69 cfs (310 gpm) in May 1992. Stream flow measurements are included in Appendix B.

Stream flow measurements were made at Location "C" (Figure 3-1) on Crutcho Creek by using an existing concrete dam as a broad crested rectangular weir in July 1991 and by using V-notch weir methods in February 1992 and May 1992. The existing low concrete dam at this location is similar to the concrete dam shown in Figure 3-2, except the weir plate is missing. In July 1991, the depth of water flowing through the rectangular broad crested weir was measured and the Energy Equation was used to calculate the flow. In February and May 1992, an aluminum 90 degree V-notch weir plate was installed in the rectangular opening in the concrete dam by using bentonite clay to seal around the weir plate. The flow through the weir was allowed to stabilize overnight and then the previously described V-notch weir flow measurement procedures were performed. The weir plate was left in place after completion of the May 1992 flow measurement activities.

The flow at Location "C" was calculated to be 0.11 cfs (49 gpm) in July 1991, 0.12 cfs (56 gpm) in February 1992, and 0.02 cfs (10 gpm) in May 1992. Stream flow measurements are included in Appendix B.



LOCATION B PROFILE

1" = 5'

FIGURE 3-3

NOTE:

WATER LEVEL MEASURED ON 2-9-92.

HALLIBURTON NUS
Environmental Corporation

TITLE

STREAM FLOW LOCATION "B" PROFILE

TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

DRAWING NO. 3K92G005

DATE 4-24-92

3.1.4 Interaction of Surface Water and Groundwater

During the February and May 1992 field activities, the surficial aquifer groundwater elevation and the adjacent surface water elevation in Crutcho Creek were measured at three locations to determine the relationship between surface water and the shallow aquifer. The groundwater elevation was measured in monitoring wells MW1A, MW5A, and MW6 by using an ESI Electronic Water Level Indicator; the elevation of the adjacent surface water was measured by using an engineering level and leveling rod. The location of these wells is shown in Figure 3-4 and the measured water elevations are shown below:

Date	Location	Screened Interval (ft)	Groundwater Elevation	Surface Water Elevation	Comments
2/7/92	MW1A	37.8-41.8	1192.77	1210.74	MW1A is screened below the surficial aquifer
2/7/92	MW5A	23.8-28.8	1215.13	1212.89	Aquifer discharge area
2/7/92	MW6	22.2-27.2	1233.62	1233.27	Aquifer discharge area
5/8/92	MW1A	37.8-41.8	1192.78	1210.64	See comments above
5/8/92	MW5A	23.8-28.8	1215.60	1212.83	See comments above
5/8/92	MW6	22.2-27.2	1233.14	1233.29	See comments above

The water elevation readings at MW5A indicate that the shallow aquifer is discharging to the surface water in these areas. The surface water and shallow aquifer at MW6 appears to be closely interconnected with the surface water being recharged by the shallow aquifer in February 1992 and the aquifer recharging the surface water in May 1992. MW1A is screened below the shallow surficial aquifer and shows a lower potentiometric head than wells MW5A and MW6, which suggests that a downward groundwater gradient is present. From these data, it appears that, generally, Crutcho Creek is fed by the shallow aquifer but that this relationship varies seasonally and spatially along the creek. It also appears that there is a downward groundwater gradient toward the Garber-Wellington Aquifer. This observation is in agreement with previous studies (USACOE 1988) which have documented that Tinker AFB is located in a recharge area for the Garber-Wellington Aquifer.

3.1.5 Storm Sewer Outfall Verification

Storm sewer outfall locations originating in industrial areas and identified during the Storm Sewer Investigation for Crutcho and Kuhlman Creeks (HALLIBURTON NUS 1990) were verified in the field during the February 1992 field activities. Several storm sewer outfalls located in residential areas were observed during the verification of industrial outfalls but verification of their locations is not included in this investigation. Field verification was performed by walking along Crutcho and Kuhlman Creeks and plotting storm sewer outfall locations on a base map. In addition to verifying the outfall locations identified during the previous storm sewer investigation, HALLIBURTON NUS personnel identified several new or modified storm sewer outfalls in the industrial area. Industrial storm sewer outfall locations are shown in Figure 3-4.

Eight storm sewer outfalls originating from industrial areas were verified on Kuhlman Creek. These outfalls were identified during the Storm Sewer Investigation and are listed in Table 3-9. The outfall verification data shown in Table 3-9 present three changes to the storm sewer outfall specifications provided in the storm sewer investigation report. The size of Outfall "B" has been changed from a 96 inch x 120 inch concrete culvert to a 72 inch x 96 inch concrete culvert, and the creek has been modified to flow in a covered concrete channel at Outfalls "G" and "H." Outfalls "G" and "H" were not verified in the field but were observed from photographs taken prior to construction of the concrete channel.

Eight storm sewer outfalls originating from industrial areas were observed on Crutcho Creek. Five of these outfalls were identified during the Storm Sewer Investigation. Two of the outfalls are new and the other outfall may have been abandoned previously but was discharging a flow of approximately 1 gpm in February 1992. These outfalls are listed in Table 3-10. Storm sewer Outfall "A" has been modified and Outfall "C" has been added due to the construction of the Navy facility on the southeastern section of Tinker AFB. Outfall "A," previously a single 60-inch-diameter pipe, has been replaced with three 72-inch-diameter pipes. Outfall "C," a 24-inch-diameter pipe draining a section of the runway, has been added. The description of Outfall "D" has been changed to reflect the presence of only one 84-inch-diameter pipe and Outfall "E," which could not be located, is believed to be present but submerged in water ponded by a beaver dam. Outfall "H" is a new outfall installed to drain the Aircraft Fire Fighting Foam Neutralization Basin and Outlet "I" may have previously been abandoned, but was discharging water in February 1992.

One pipeline north of Building 1030 was dye-tested to determine if it discharged into Crutcho Creek or into the industrial waste sewer. This test was performed by introducing fluorescent red dye (rhodamine) into water flowing in a manhole near the northeast corner of Building 1030 and by

TABLE 3-9

KUHLMAN CREEK INDUSTRIAL STORM SEWER OUTFALLS
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Outfall Letter	Diameter (inches)	Comments[a]
A	60 RCP	No change.
B	72 x 96 Concrete Culvert	Size changed from 96 x 120 to 96 x 72.
C	36 RCP	No change. Outfall partially blocked by debris.
D	72 RCP	No change.
E	42 RCP	No change.
F	21 RCP	No change.
G	60 RCP	Outfall is present but has been bridged over and was not field verified.
H	72 RCP	Outfall is present but has been bridged over and was not field verified.

(a) "No change" indicates that the outfall descriptions included in the Storm Sewer Investigation of Crutcho and Kuhlman Creeks (HALLIBURTON NUS 1990) have not been revised.

RCP Reinforced concrete pipe.

TABLE 3-10

CRUTCHO CREEK INDUSTRIAL STORM SEWER OUTFALLS
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Outfall Letter	Diameter (inches)	Comments[a]
A	3-72 RCP	Changed from one 60-inch RCP.
B	72 RCP	No change.
C	24 RCP	New outfall.
D	84 CMP	Changed from two to one pipes.
E	6 CMP	This outfall was not found. Beavers have ponded water in this area.
F	30 CMP	No change. Outfall was partially blocked with sediment.
G	21 RCP	No change.
H	6 PVC	New outfall from Aircraft Fire Fighting Foam Neutralization Basin.
I	24 Clay pipe	This outfall may have been abandoned but was discharging a flow of approximately 1 gpm in February 1992.

(a) "No change" indicates that the outfall descriptions included in the Storm Sewer Investigation of Crutcho and Kuhlman Creeks (HALLIBURTON NUS 1990) have not been revised.

RCP Reinforced concrete pipe.
CMP Corrugated metal pipe.
PVC Polyvinyl chloride pipe.

monitoring the color of the water at a manhole adjacent to the northwest corner of Building 1030 and near the oil/water separator, which discharges through Crutcho Creek Outfall "F." This test confirmed that the pipeline was an industrial waste sewer pipeline that did not discharge into Crutcho Creek. The dye used for this test was allowed to flow to the industrial wastewater treatment plant since it is biodegradable and considered environmentally safe.

The discharges from a pipeline located at Building 1068 (constructed after the original storm sewer investigation) were verified by base personnel involved with construction of this building. From these discussions, it was determined that all water used inside the building discharges to the industrial waste sewer and that the grate outside the building discharges into the Aircraft Fire Fighting Foam Neutralization Basin.

3.2 ANALYTICAL METHODS AND PROCEDURES

All sediment and most surface water samples were analyzed by HALLIBURTON NUS Environmental Laboratories in Pittsburgh, Pennsylvania, and Houston, Texas. Surface water samples analyzed for Biochemical Oxygen Demand (BOD), MBAs, nitrites, and turbidity were hand-delivered to a local laboratory, Alpha Analytical Laboratories in Oklahoma City, Oklahoma, due to the samples' short holding times. Water samples to be analyzed for organophosporous pesticides were analyzed by Resources Analysts, Inc. in Hampton, New Hampshire.

Surface water samples were chemically preserved except for the Cl samples, which were unpreserved. Sediment samples were not preserved. Samples were placed on ice after collection and kept on ice until shipment. The samples were sent by Federal Express for next day delivery to their respective laboratories. Sample shipments are documented on the chain-of-custody forms provided in Appendix C.

3.2.1 Data Quality Objectives

Data quality objectives (DQOs) are statements which specify the quality of data required to support health and environmental assessments or engineering (remediation) decisions throughout the RI process. Analytical requirements, Quality Assurance/Quality Control (QA/QC) measures, and validation criteria are established to support DQOs. DQOs consider the end use of the data and the degree of certainty with respect to precision, accuracy, representativeness, completeness, and comparability (the PARCC parameters) needed to satisfy the end use of the data (USEPA 1989). The broad objectives for data collection include:

- Collection of technically defensible data describing the nature of site contamination, if any.

- Collection of sufficient data for responsible decisions regarding disposition of the site and investigation wastes.

- Protection of personnel during field activities.

HAZWRAP has proposed standard laboratory QC requirements in a document entitled, Hazardous Waste Remedial Actions Program (HAZWRAP) Requirements for Quality Control of Analytical Data (Martin Marietta Energy Systems July 1990). Five options are defined in this document (Levels A, B, C, D, and E), based on site characteristics, the DQOs, and laboratory delivery requirements. These levels correspond synonymously to EPA QC Levels 1 through 5. Level A QC was used during the RI for health and safety monitoring instruments and miscellaneous sampling equipment, such as pH meters. The sediment and groundwater samples collected in July 1991 were analyzed in accordance with Level D QC. February and May 1992 analyses were performed using Level C QC. The Laboratory Quality Assurance Plans (LQAP) used for the RI are provided in Appendix D. HAZWRAP's description of QC Levels A, C, and D is included in the following subsections.

3.2.1.1 Level A Quality Control

Data meeting Level A criteria are qualitative or semi-quantitative in nature and are used as indicator parameters. Data are obtained by use of approved field equipment, such as total organic vapor analyzers, colorimetric indicator kits, dissolved oxygen meters, and geophysical survey instruments. Other instruments and methods may be used, if approved by the HAZWRAP Project Manager. Equipment capability, or the analytical QC implemented, will limit the data obtained as qualitative, or at best, semi-quantitative. Quantitative data are not obtained on an analyte-specific basis. Level A data may be used for the following: (1) delineation of contaminated zones, (2) gross determination of analytes in samples, or (3) health and safety screening. Level A data can provide information to the in-house laboratory regarding expected concentration ranges. This information can assist the laboratory in determining applicable analytical ranges.

3.2.1.2 Level C Quality Control

Level C QC would be required at a site near a populated area, not on the National Priority List (NPL), and not likely to be undergoing litigation. Level C QC includes review of the LQAP and project work plan, including the QAPP. The laboratory shall successfully analyze a performance evaluation (PE)

sample, undergo an audit, correct deficiencies found during the audit, and provide monthly progress reports on QC. Level C provides low detection limits, a wide range of calibrated analytes, matrix recovery information, laboratory process control information, and known precision and accuracy. EPA-accepted methods, such as the Contract Laboratory Program (CLP), are utilized under Level C. Advantages of Level C QC are (1) greater precision and accuracy than Levels A and B and (2) more established and documented QC. Level C can be used for risk assessment, while Levels A and B cannot. A disadvantage is the time required to obtain data (typically 20 to 30 days). These data may be used for risk assessment, site characterization, evaluation of alternatives, engineering design, and monitoring during implementation.

3.2.1.3 Level D Quality Control

Level D QC is used when comprehensive data quality documentation is required. Typically, this level is needed for select samples at NPL sites. These sites are typically near populated areas and are likely to undergo litigation. Level D QC includes review of the LQAP and project work plan, including the QAPP. The laboratory shall successfully analyze a PE sample, undergo an audit, correct deficiencies found during the audit, and provide MPRs on QC. For Level D, CLP methods and full data package deliverables are required for analyses covered by these methods. Methods not included in the CLP will be elevated to Level D by including appropriate QC samples and submitting all raw sample and calibration data. An advantage of Level D QC is that methods are accepted by all EPA states, regions, and courts. The methods provide the most documented information on matrix effects and on precision and accuracy of all environmental methods. Methods are detailed; therefore, more consistency between laboratories is observed. Because raw sample data, calibration, and QC documentation are presented, the reviewer can fully assess data quality. Disadvantages are 30 to 40 day turnaround, large quantities of data for storage and review, and higher costs. These data may be used for risk assessment, site characterization, evaluation of alternatives, engineering design, and monitoring implementation.

3.2.2 Fixed Base Laboratory Methods

The fixed base laboratory analyses for this RI were performed using HAZWRAP Level C and D protocols, which are synonymous with CLP EPA Levels 3 and 4 data quality objectives. The analytical methods, QA/QC, and reporting requirements are found in the following:

- Appendix IX VOCs and SVOCs - Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition and Laboratory Quality Assurance Project Plan (Appendix D).

- Target Analyte List (TAL) Inorganics plus Cyanide - Statement of Work for Inorganics Analysis, Multi-Media, and Multi-Concentration (USEPA CLP 1988b).

- Target Compound List (TCL) Pesticides/PCBs plus Organophosphorus Pesticides - Statement of Work for Organic Analysis, Multi-Media, and Multi-Concentration (USEPA CLP 1988a).

- Miscellaneous Organics, Inorganics and Radio Chemistry - Methods for Chemical Analysis of Water and Wastes (EPA-600) and Standard Methods for the Examination of Water and Wastewater, 16th Edition (EPA 1979a and EPA 1986c).

VOC and SVOC analyses were performed using gas chromatography/mass spectrometry (GC/MS) methodology. A purge-and-trap technique was used for VOCs. A preliminary extraction using methylene chloride was performed and introduced into the GC/MS for quantitation of SVOCs. The complete VOC and SVOC analyte lists can be found in Appendix D.

Following preliminary acid digestion, most of the 23 inorganics were measured by inductively-coupled plasma (ICP). The ICP uses atomic emission techniques to determine analyte concentration. For metals for which the ICP did not have sufficient sensitivity to achieve the Contract Required Detection Limits (CRDLs) as specified in the protocol, a graphite furnace atomic absorption (AA) spectrometer was used. Mercury was measured using a separate cold-vapor AA technique.

Cyanide was measured by a distillation and colorimetric technique in which cyanide gas, released after acidification, was trapped in a highly basic medium (sodium hydroxide). The sodium hydroxide solution was buffered, chlorinated, and treated with pyridine-barbituric acid. The color intensity of the solution is proportional to the concentration of cyanide in the sodium hydroxide scrubber solution.

3.2.3 Data Validation

Formal data validation performs three basic functions. It serves as an independent QA check of the veracity of laboratory results; it is a means of evaluating laboratory performance and determining the impact of noncompliances on the data; and, through the use of data qualifiers, it lends interpretive guidance as to the proper usage and limitations of the data.

Formal data validation is a systematic review and evaluation of the data conducted according to the following EPA National Protocols:

- Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (USEPA 1988c).
- Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses (USEPA 1988a).

In accordance with the National Protocols, organic data were evaluated based on the following:

- Data completeness
- Holding times
- GC/MS tuning and mass calibration
- Initial and continuing calibration
- Laboratory blank analyses
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate analyses
- Internal standards performance
- Detection limits
- Sample quantitation
- Field duplicates
- Compound identification
- System performance
- Tentatively Identified Compounds

In accordance with National Protocols, inorganic data were evaluated based on the following:

- Data completeness
- Holding times
- Initial and continuing calibration verification
- Interference check sample results
- Laboratory control sample results
- Furnace AA results
- Blanks
- Field duplicates
- Matrix spikes/matrix spike duplicates
- Sample quantitation
- Serial dilutions

4.0 NATURE AND EXTENT OF CONTAMINATION

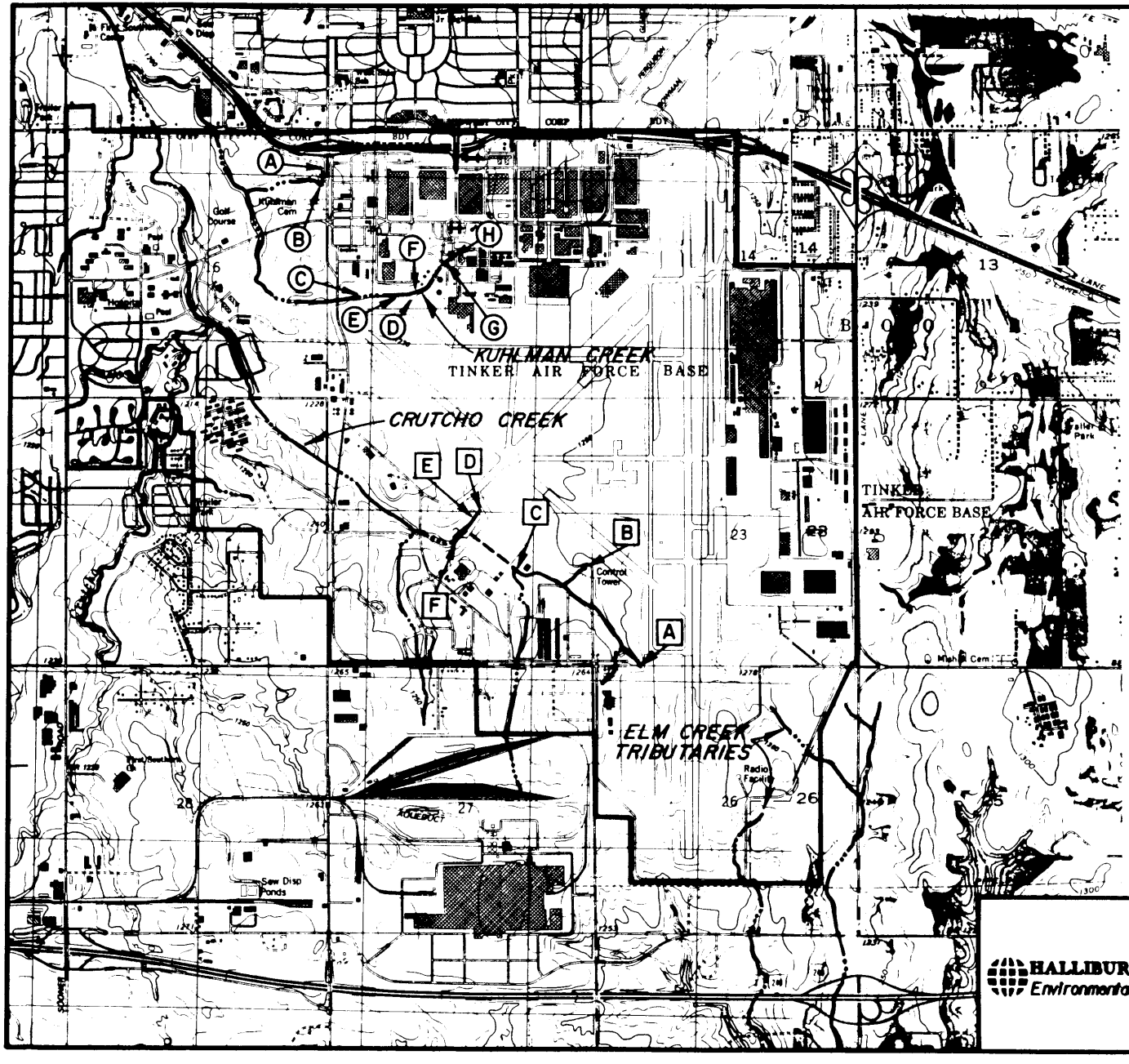
4.1 PREVIOUS INVESTIGATION

As a result of industrial operations, Tinker AFB generates and disposes of a variety of solid and hazardous waste. Historically, the majority of this waste has been either treated at the base wastewater treatment plant or disposed of in base landfills. Environmental studies have been performed at the base to investigate the potential for contamination in soil, surface water, and groundwater resulting from base activities. These investigations confirmed that releases of organic and inorganic contamination had occurred at the plating shop facility (i.e., Building 3001), storm sewer outfalls along Soldier Creek, and at several base landfills. Subsequently, Building 3001 and Soldier Creek were placed on the CERCLA NPL and remedial design was initiated. Corrective measures have also begun at several base landfills.

HALLIBURTON NUS performed an investigation of storm sewers discharging into Crutcho and Kuhlman Creeks between October 1988 and June 1989. This investigation, entitled Storm Sewer Investigation for Crutcho And Kuhlman Creeks (September 1990), was conducted to identify intermittent releases of potentially hazardous contaminants from the storm sewers to the creek system. Water quality samples were collected at 9 of the 14 storm sewer outfall locations shown in Figure 4-1. These samples were analyzed for the following parameters:

- Volatile Organics
- Oil and Grease
- Inorganics (cadmium, chromium, copper, lead, nickel, phosphorous, and zinc)
- MBAS
- COD
- Cyanide
- Total Phenols

No detectable concentrations of inorganics, cyanide, or total phenols were present in any of the water samples. However, the resulting values for COD and oil and grease at several outfall locations exceeded the National Pollutant Discharge Elimination System (NPDES) permit limits. Also, six VOCs exceeded the MCLs at two storm sewer outfalls. They were benzene, 1,1,1-trichloroethane, and 1,1-dichloroethene in Outfall "G" on Kuhlman Creek, and trichloroethene, trans-1,2-dichloroethane, vinyl chloride, and tetrachloroethene in Outfall "F" on Crutcho Creek. The VOC concentrations are compared with analytical data from the July and February sampling effort in Section 4.6.



LEGEND

- INSTALLATION BOUNDARY
- CREEK
- STORM SEWER OUTFALL LOCATION
  - KUHLMAN CREEK (A)
  - CRUTCHO CREEK [A]

NOTES:

1) BASE MAP TAKEN FROM MIDWEST CITY (1986 EDITION) AND CHOCTAW, OKLAHOMA (1975 EDITION) U.S.G.S. 7.5' TOPOGRAPHIC QUADRANGLES.
2) STORM SEWER OUTFALL LOCATIONS TAKEN FROM MASTER PLAN - STORM SEWER SYSTEM (3-5-71) DRAWING PROVIDED BY TINKER AIR FORCE BASE.

N

GRAPHIC SCALE

2000' 0 2000' 4000' 6000'

FIGURE 4-1

HALLIBURTON NUS Environmental Corporation

TITLE: STORM SEWER INVESTIGATION OUTFALL LOCATION MAP
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

DRAWING NO. 3K92G001 DATE 4-17-92

4.2 BASELINE DATA COLLECTION

Baseline sediment and surface water samples were collected July 4–8 and October 26–28, 1991, from 27 of the 29 sample locations as shown in Figure 3-1. Locations 17A and 22A were not sampled as part of the baseline data collection activities. Nineteen locations are on Crutcho Creek. Six sampling locations (1 through 5, and 27) are on Kuhlman Creek. The remaining four locations (22, 22A, 23, and 24) are on the tributaries of Elm Creek. Due to low base flow conditions, only sediment samples were collected from Locations 13, 23, 24, 25, and 27 in July 1991. Surface water samples were collected from these locations in October 1991.

The July and October 1991 samples were analyzed for the chemical parameters shown previously in Tables 3-1 and 3-2. The analytical data are presented in Tables 4-1 through 4-11. The laboratory reports are included as Appendix E. These reports are separated into groups that correspond to their respective data table (e.g., Table 4-1 = Group E-1, Table 4-2 = Group E-2).

4.2.1 Sediment Sample Results

The analytical results for inorganics in July 1991 sediment samples are shown in Table 4-1. Each sediment sample was analyzed for 26 target inorganics. Seventeen inorganics were present in concentrations above the laboratory detection limit. These inorganics are listed below with the highest reported value and associated sample number.

Inorganic	Value[a]	Sample Number[b]
Aluminum	9230	SD22E
Antimony	1.7J	SD25
Arsenic	13.5J	SD12
Barium	2240J	SD06
Beryllium[c]	1.0	SD13
Calcium	62800J	SD11
Chromium	318	SD24
Copper	23.7	SD25
Iron	11300J	SD22
Lead	309J	SD26
Magnesium	7360J	SD16
Manganese	1400J	SD16
Mercury	0.19	SD07
Potassium	1400	SD22
Selenium	0.36J	SD25
Vanadium	63J	SD23
Zinc	97.7	SD25

(a) Maximum values reported in milligrams/kilograms (mg/kg).
(b) Sample number of maximum value.
(c) This inorganic only found in one sediment sample, SD13.

TABLE 4-1

INORGANICS IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek									
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD07F	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	2620	NS	NS	NS	NS	2170	3370	NS	NS	NS	NS	NS	1430	NS	NS
Antimony	0.76 UJ	0.96 J	0.74 UJ	0.79 UJ	0.80 UJ	0.76 UJ	0.76 UJ	0.84 UJ	0.79 UJ	0.76 UJ	1.0 J	0.99 J	0.72 UJ	0.78 UJ	0.73 UJ
Arsenic	0.60 J	1.2 J	2.2 J	1.5 J	3.2 J	0.92 J	0.88 J	2.5 J	2.4 J	5.1 J	2.4 J	6.8 J	0.93 J	13.5 J	2.0 J
Barium	2060 J	545 J	561 J	354 J	248 J	2240 J	1470 J	835 J	612 J	1200 J	1180 J	1100 J	674 J	1070 J	505 J
Beryllium	1.0 U	0.93 U	0.98 U	0.79 U	0.37 U	0.99 U	0.69 U	0.95 U	0.85 U	1.0 U	0.81 U	0.82 U	0.63 U	0.65 U	1.0
Boron	25.5 UJ	NS	NS	NS	NS	25.3 UJ	25.4 UJ	NS	NS	NS	NS	NS	24.0 U	NS	NS
Cadmium	0.76 U	0.76 U	1.0 U	1.8 U	0.80 UJ	0.76 U	1.0 U	0.92 U	1.4 U	0.76 U	0.76 U	0.77 U	0.72 UJ	0.78 UJ	0.73 U
Calcium	41700	NS	NS	NS	NS	13400	12300	NS	NS	NS	NS	NS	62800 J	NS	NS
Chromium	7.9	16.1	10.6	16.5	29.4 J	8.2	10.3	22.5	22.8	14.5	8.2	8.9	7.3 J	9.3 J	23.8
Cobalt	7.1 U	10.0 U	8.8 U	9.7 U	5.3 U	4.6 U	6.0 U	6.2 U	8.3 U	13.9 U	10.8 U	11.3 U	2.2 U	14.6 U	14.2 U
Copper	3.9 J	10.1	5.0 J	14.7	14.6	2.5 UJ	3.4 J	7.5	6.8	9.5	6.5	8.0	2.4 U	6.9	10.0
Cyanide	0.63 U	NS	NS	NS	NS	0.64 U	0.66 U	NS	NS	NS	NS	NS	0.64 U	NS	NS
Iron	5680 J	NS	NS	NS	NS	2690 J	3950 J	NS	NS	NS	NS	NS	6240 J	NS	NS
Lead	49.4	14.3	15.4	62.4	47.3 J	3.7	5.5	10.4	8.7	12.7	4.6	8.5	11.2 J	21.0 J	7.6
Magnesium	3410 J	NS	NS	NS	NS	4790 J	4840 J	NS	NS	NS	NS	NS	4860 J	NS	NS
Manganese	522 J	NS	NS	NS	NS	373 J	470 J	NS	NS	NS	NS	NS	338 J	NS	NS
Mercury	0.06 U	0.06	0.05 U	0.07 U	0.06 U	0.07 U	0.06 U	0.07 U	0.19	0.06	0.06 U	0.05 U	0.05 U	0.06 U	0.05 U
Nickel	12.4 U	13.0 U	6.6 U	10.4 U	9.0 U	9.3 U	9.0 U	16.8 U	15.4 U	11.9 U	9.7 U	12.3 U	3.9 U	10.6 U	23.7 U
Potassium	375	NS	NS	NS	NS	274	429	NS	NS	NS	NS	NS	155	NS	NS
Selenium	0.25 U	0.26 U	0.24 U	0.27U	0.28 UJ	0.26 U	0.25 U	0.29 U	0.25U	0.25 UJ	0.25 U	0.28 J	.0.24 UJ	0.27 UJ	0.24 U
Silver	1.2 U	1.3 U	1.2 U	1.3 U	1.4 R	1.3 U	1.3 U	1.4U	1.3U	1.2U	1.3U	1.3 U	1.2 R	1.3 R	1.2 U
Sodium	688 UJ	NS	NS	NS	NS	683 UJ	686 UJ	NS	NS	NS	NS	NS	649 U	NS	NS
Strontium	25.5 U	NS	NS	NS	NS	25.3U	25.4 U	NS	NS	NS	NS	NS	24.0 U	NS	NS
Thallium	0.50 UJ	0.49 UJ	0.47 UJ	0.53 UJ	0.53 UJ	0.51 UJ	0.52 UJ	0.55 UJ	0.52 UJ	0.49 UJ	0.51 UJ	0.48 UJ	0.49 UJ	0.52 U	0.49 UJ
Vanadium	3.1 J	31.0 J	21.1 J	18.2 J	8.6	2.3 UJ	10.9 J	23.5 J	18.5 J	31.8 J	21.3 J	30.1 J	17.3	55.1	39.5 J
Zinc	31.7	54.7	46.6	60.4	94.7	12.9 U	16.9	29.8	25.4	37.6	24.9	23.3	26.6	29.3	37.4

Data Qualifier Legend
(a) - Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-1

INORGANICS IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Crutcho Creek											Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD25F	SD26E	SD22E	SD23E	SD24E
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	NS	NS	5910	NS	NS	NS	NS	3330	NS	NS	NS	9230	NS	NS
Antimony	0.70 UJ	0.77 UJ	0.76 UJ	0.79 UJ	0.79 UJ	0.75 UJ	0.81 UJ	0.79 UJ	1.7 J	0.81 J	0.84 UJ	0.81 UJ	1.1 J	0.99 J
Arsenic	3.7 J	1.2 J	2.0 J	2.0 J	2.6 J	3.5 J	2.5 J	2.2 J	4.0 J	3.7 J	2.2 J	0.97 J	2.3 J	3.7 J
Barium	979 J	762 J	815 J	621 J	554 J	1120 J	451 J	311 J	658 J	918 J	629 J	274 J	552 J	582 J
Beryllium	0.74 U	0.46 U	0.66 U	0.47 U	0.42 U	0.60 U	0.43 U	0.37 U	0.60 U	0.66 U	0.61 U	1.0 U	1.1 U	1.2 U
Boron	NS	NS	25.5 U	NS	NS	NS	NS	26.2 U	NS	NS	NS	27.0 UJ	NS	NS
Cadmium	0.70 U	0.77 UJ	0.79 U	1.1 U	0.79 UJ	0.75 UJ	0.80 UJ	0.79 UJ	3.4 U	2.9 U	0.84 UJ	0.81 U	0.82 U	4.2 U
Calcium	NS	NS	22500 J	NS	NS	NS	NS	6440 J	NS	NS	NS	1810	NS	NS
Chromium	6.7	40.9 J	49.1 J	37.3 J	26.5 J	35.3 J	11.4 J	17.1 J	15.4 J	18.4 J	8.2 J	15.0	27.4	318
Cobalt	8.6 U	5.0 U	9.8 U	7.5 U	7.1 U	13.9 U	8.0 U	4.2 U	13.2 U	15.4 U	6.5 U	9.1 U	16.2 U	12.7 U
Copper	8.5	6.5	3.2	8.1	6.1	9.7	4.6	3.5	23.2	23.7	6.5	3.5 J	10.9	11.2
Cyanide	NS	NS	0.65 U	NS	NS	NS	NS	NS	NS	NS	NS	0.70 U	NS	NS
Iron	NS	NS	10200 J	NS	NS	NS	NS	4720 J	NS	NS	NS	11300 J	NS	NS
Lead	7.9	8.7 J	19.1 J	20.0 J	17.7 J	21.3 J	8.3 J	10.6 J	75.3 J	123 J	309 J	5.4	10.5	26.2
Magnesium	NS	NS	7360 J	NS	NS	NS	NS	2470 J	NS	NS	NS	2240 J	NS	NS
Manganese	NS	NS	1400 J	NS	NS	NS	NS	388 J	NS	NS	NS	454 J	NS	NS
Mercury	0.05 U	0.06 U	0.07 U	0.06 U	0.06 U	0.06 U	0.07 U	0.06 U	0.07 U	0.06 U	0.06 U	0.07	0.07 U	0.07 U
Nickel	13.7 U	9.6 U	12.9 U	11.9 U	8.4 U	11.6 U	9.7 U	4.8 U	14.3 U	21.9 U	9.5 U	14.5 U	30.5 U	21.9 U
Potassium	NS	NS	728	NS	NS	NS	NS	451	NS	NS	NS	1400	NS	NS
Selenium	0.24 UJ	0.26 UJ	0.26 UJ	0.26 UJ	0.26 UJ	0.26 UJ	0.27 UJ	0.27 UJ	0.29 J	0.36 J	0.29 UJ	0.27 U	0.27 U	0.28 U
Silver	1.2 U	1.3 R	1.3 R	1.3 R	1.3 R	1.3 R	1.4 R	1.3 R	1.3 R	8.5 J	1.4 R	1.3 U	1.4 U	1.4 U
Sodium	NS	NS	687 U	NS	NS	NS	NS	708 U	NS	NS	NS	729 UJ	NS	NS
Strontium	NS	NS	25.5 U	NS	NS	NS	NS	26.2 U	NS	NS	NS	27.0 U	NS	NS
Thallium	0.48 UJ	0.51 UJ	0.51 UJ	0.53 U	0.52 U	0.51 U	0.55 U	0.52 U	0.50 U	0.51 U	0.55 U	0.55 UJ	0.54 UJ	0.55 UJ
Vanadium	13.0 J	15.5	22.4	20.4	19.8	43.3	22.2	8.7	23.8	29.9	21.0	15.1 J	63.0 J	61.0 J
Zinc	16.6	27.1	30.1	31.3	37.0	39.3	36.9	23.8	97.7	89.2	59.1	24.4	54.9	60.0

Data Qualifier Legend
(a) - Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quanititation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
N-Nitrosodimethylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Phenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Aniline	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
bis(2-Chloroethyl)ether	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2-Chlorophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,3-Dichlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,4-Dichlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Benzyl alcohol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,2-Dichlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2-Methylphenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
bis(2-Chloroisopropyl)ether	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Methylphenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitroso-Di-n-propylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Hexachloroethane	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Nitrobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Isophorone	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2-Nitrophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,4-Dimethylphenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
bis(2-Chloroethoxy)Methane	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,4-Dichlorophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,2,4-Trichlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Naphthalene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Chloroaniline	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Hexachlorobutadiene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
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Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
4-Chloro-3-Methylphenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2-Methylnaphthalene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Hexachlorocyclopentadien	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,4,6-Trichlorophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,4,5-Trichlorophenol	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	410 U	NS	NS
2-Chloronaphthalene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	2000 U	NS	NS
2-Nitroaniline	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	410 U	NS	NS
Dimethyl phthalate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	2000 U	NS	NS
Acenaphthylene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,6-Dinitrotoluene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
3-Nitroaniline	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	410 U	NS	NS
Acenaphthene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	2000 U	NS	NS
2,4-Dinitrophenol	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	410 U	NS	NS
4-Nitrophenol	2000 UJ	NS	NS	NS	NS	2100 UJ	2100 U	NS	NS	NS	NS	2000 U	NS	NS
Dibenzofuran	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	2000 UJ	NS	NS
2,4-Dinitrotoluene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Diethylphthalate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Chlorophenyl phenyl ether	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Fluorene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Nitroaniline	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	2000 U	NS	NS
4,6-Dinitro-2-Methyl Phenol	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	2000 U	NS	NS
N-Nitrosodiphenylamine(1)	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Bromophenyl -phenyl ether	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS

Data Qualifier Legend

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TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Hexachlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Pentachlorophenol	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	2000 U	NS	NS
Phenanthrene	890	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Anthracene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Di-n-butyl phthalate	420 U	NS	NS	NS	NS	400 BJ	430 U	NS	NS	NS	NS	410 U	NS	NS
Fluoranthene	1300	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Pyrene	820	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Butylbenzyl phthalate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
3,3'Dichlorobenzidine	840 U	NS	NS	NS	NS	850 U	870 U	NS	NS	NS	NS	820 U	NS	NS
Benzo(a)anthracene	410 J	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Chrysene	500	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
bis(2-Ethylhexyl)phthalate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Di-n-octyl phthalate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	75 J	NS	NS
Benzo(b)fluoranthene	700	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Benzo(k)fluoranthene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Benzo(a)pyrene	350 J	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Indeno(1,2,3-cd)pyrene	210 J	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Dibenzo(a,h)anthracene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Benzo(g,h,i) Perylene	230 J	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,3,4,6-Tetrachlorophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
PyrAdine, 2-Methyl(2-Picolin)	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Methanesulfonic Acid Ethyl	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitrosopiperidine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2,6-Dichlorophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitroso-Di-n-butylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Methanesulfonic Acid, Methyl	420 UJ	NS	NS	NS	NS	420 UJ	430 UJ	NS	NS	NS	NS	410 UJ	NS	NS

Data Qualifier Legend

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U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.
B - Compound detected in blank sample.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Acetophenone	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
A,A-Dimethylphenethylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Pentachlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Aminobiphenyl	420 UJ	NS	NS	NS	NS	420 UJ	430 UJ	NS	NS	NS	NS	410 UJ	NS	NS
p-Dimethylamino-azobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
7,12-Dimethylbenzo(a) anthracene	420 UJ	NS	NS	NS	NS	420 UJ	430 UJ	NS	NS	NS	NS	410 UJ	NS	NS
1,2,4,5-Tetrachlorobenzene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Diphenylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Phenacetin	420 U	NS	NS	S	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
3-Methylcholanthrene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Pronamide	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,4-Benzenediamine	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	2000 U	NS	NS
Isosafrole	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2-Napthaleneamine	420 UJ	NS	NS	NS	NS	420 UJ	430 U	NS	NS	NS	NS	410 UJ	NS	NS
5-Nitro-o-toluidine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
4-Nitroquinoline 1-oxide	2000 U	NS	NS	NS	NS	2100 U	2100 U	NS	NS	NS	NS	2000 U	NS	NS
Methapyrilene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
2-Acetylaminofluorene	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitrosomethylethylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitrosodiethylamine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitrosopyrrolidine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
N-Nitrosomorpholine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
o-Toluidine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS

Data Qualifier Legend

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Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FIVE

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
0,0,0-Triethyl - phosphorthioat	2,000 U	NS	NS	NS	NS	2,100 U	2,100 U	NS	NS	NS	NS	2,000 U	NS	NS
Pentachloronitrobenzene	2,000 R	NS	NS	NS	NS	2,100 R	2,100 U	NS	NS	NS	NS	2,000 R	NS	NS
Safrole	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,4-Naphthoquinone	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
1,3,5-Trinitrobenzene	2,000 U	NS	NS	NS	NS	2,100 U	2,100 U	NS	NS	NS	NS	2,000 U	NS	NS
Hexachloropropene	2,000 U	NS	NS	NS	NS	2,100 U	2,100 U	NS	NS	NS	NS	2,000 U	NS	NS
1,3-Dinitrobenzene	2,000 U	NS	NS	NS	NS	2,100 U	2,100 U	NS	NS	NS	NS	2,000 U	NS	NS
3,3'-Dimethylbenzidine	2,000 U	NS	NS	NS	NS	2,100 U	2,100 U	NS	NS	NS	NS	2,000 U	NS	NS
Hexachlorophene	2,000 U	NS	NS	NS	NS	2,100 U	2,100 U	NS	NS	NS	NS	2,000 U	NS	NS
Dimethoate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Diallate	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Pyridine	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
Aramite	2,000 U	NS	NS	NS	NS	2,100 U	2,100 R	NS	NS	NS	NS	2,000 U	NS	NS
2-Secbutyl-4,6-Dinitrophenol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS
M-Cresol	420 U	NS	NS	NS	NS	420 U	430 U	NS	NS	NS	NS	410 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected abovethe associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE SIX

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
N-Nitrosodimethylamine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Phenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Aniline	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
bis(2-Chloroethyl)ether	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Chlorophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,3-Dichlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,4-Dichlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Benzyl alcohol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,2-Dichlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Methylphenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
bis(2-Chloroisopropyl)ether	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Methylphenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitroso-Di-n-propylamine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Hexachloroethane	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Nitrobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Isophorone	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Nitrophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,4-Dimethylphenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
bis(2-Chloroethoxy) Methane	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,4-Dichlorophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,2,4-Trichlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Naphthalene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Chloroaniline	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Hexachlorobutadiene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE SEVEN

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
4-Chloro-3-Methylphenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Methylnaphthalene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Hexachlorocyclopentadien	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,4,6-Trichlorophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,4,5-Trichlorophenol	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
2-Chloronaphthalene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Nitroaniline	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Dimethyl phthalate	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Acenaphthylene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,6-Dinitrotoluene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
3-Nitroaniline	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Acenaphthene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,4-Dinitrophenol	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
4-Nitrophenol	NS	NS	2,100 UJ	NS	NS	NS	2,200 UJ	NS	NS	NS	NS	NS	NS
Dibenzofuran	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,4-Dinitrotoluene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Diethylphthalate	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Chlorophenyl phenyl ether	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Fluorene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Nitroaniline	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
4,6-Dinitro-2-Methyl Phenol	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
N-Nitrosodiphenylamine(1)	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Bromophenyl-phenyl ether	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated valuewhich is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE EIGHT

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Hexachlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Pentachlorophenol	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Phenanthrene	NS	NS	430 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Anthracene	NS	NS	430 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Di-n-butyl phthalate	NS	NS	430 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Fluoranthene	NS	NS	430 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Pyrene	NS	NS	430 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Butylbenzyl phthalate	NS	NS	430 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
3,3'Dichlorobenzidine	NS	NS	870 U	NS	NS	NS	920 U	NS	NS	NS	NS	NS	NS
Benzo(a)anthracene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Chrysene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
bis(2-Ethylhexyl)phthalate	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Di-n-octyl phthalate	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Benzo(b)fluoranthene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Benzo(k)fluoranthene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Benzo(a)pyrene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Indeno(1,2,3-cd)pyrene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Dibenzo(a,h)anthracene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Benzo(g,h,i) Perylene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,3,4,6-Tetrachlorophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Pyradine, 2-Methyl(2-Picolin)	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Methanesulfonic Acid Ethyl	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitrosopiperidine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2,6-Dichlorophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitroso-Di-n-butylamine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Methanesulfonic Acid, Methyl	NS	NS	430 UJ	NS	NS	NS	460 UJ	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANICS COMPOUNDS IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE NINE

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Acetophenone	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
A,A-Dimethylphenethylamin	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Pentachlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Aminobiphenyl	NS	NS	430 UJ	NS	NS	NS	460 UJ	NS	NS	NS	NS	NS	NS
p-Dimethylamino-azobenzen	NS	NS	430 U	NS	NS	NS	460 U		NS	NS	NS	NS	NS
7,12-Dimethylbenzo(a) anthracene	NS	NS	430 UJ	NS	NS	NS	460 UJ	NS	NS	NS	NS	NS	NS
1,2,4,5-Tetrachlorobenzene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Diphenylamine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Phenacetin	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
3-Methylcholanthrene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Pronamide	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,4-Benzenediamine	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Isosafrole	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Napthaleneamine	NS	NS	430 UJ	NS	NS	NS	460 UJ	NS	NS	NS	NS	NS	NS
5-Nitro-o-toluidine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
4-Nitroquinoline 1-oxide	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Methapyrilene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
2-Acetylaminofluorene	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitrosomethylethylamine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitrosodiethylamine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitrosopyrrolidine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
N-Nitrosomorpholine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
o-Toluidine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS

Data Qualifier Legend
(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-2

SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TEN

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
0,0,0-Triethyl-phosporthioat	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Pentachloronitrobenzene	NS	NS	2,100 R	NS	NS	NS	2,200 R	NS	NS	NS	NS	NS	NS
Safrole	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,4-Naphthoquinone	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
1,3,5-Trinitrobenzene	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Hexachloropropene	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
1,3-Dinitrobenzene	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
3,3'-Dimethylbenzidine	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Hexachlorophene	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
Dimethoate	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Diallate	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Pyridine	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
Aramite	NS	NS	2,100 U	NS	NS	NS	2,200 U	NS	NS	NS	NS	NS	NS
2-Secbutyl-4,6-Dinitrophenol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS
M-Cresol	NS	NS	430 U	NS	NS	NS	460 U	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled
R - Data rejected (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-3

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs) AND RADIOACTIVITY IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PESTICIDES (a)														
α-BHC	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 U	NS	NS
β-BHC	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 U	NS	NS
δ-BHC	10 U	NS	NS	NS	NS	10 UJ	11 UJ	NS	NS	NS	NS	10 U	NS	NS
γ-BHC (Lindane)	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 U	NS	NS
Heptachlor	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 U	NS	NS
Aldrin	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 U	NS	NS
Heptachlor Epoxide	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 R	NS	NS
Endosulfan I	10 U	NS	NS	NS	NS	10 U	11 U	NS	NS	NS	NS	10 U	NS	NS
Dieldrin	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 U	NS	NS
4,4'-DDE	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 U	NS	NS
Endrin	20 U	NS	NS	NS	NS	21 UJ	21 UJ	NS	NS	NS	NS	20 UJ	NS	NS
Endosulfan II	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 U	NS	NS
4,4'-DDD	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 U	NS	NS
Endosulfan Sulfate	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 UJ	NS	NS
4,4'-DDT	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 U	NS	NS
Methoxychlor	100 U	NS	NS	NS	NS	100 UJ	110 UJ	NS	NS	NS	NS	100 U	NS	NS
Endrin Ketone	20 U	NS	NS	NS	NS	21 U	21 U	NS	NS	NS	NS	20 U	NS	NS
α-Chlordane	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
δ-Chlordane	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
Toxaphene	200 U	NS	NS	NS	NS	210 U	210 U	NS	NS	NS	NS	200 U	NS	NS

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment Sample (i.e., SD06E)
F - Duplicate Sediment Sample (i.e., SD06F)

TABLE 4-3

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs) AND RADIOACTIVITY IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
POLYCHLORINATED BIPHENYLS (PCBs) (a)														
Aroclor-1016	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
Aroclor-1221	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
Aroclor-1232	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
Aroclor-1242	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
Aroclor-1248	100 U	NS	NS	NS	NS	100 U	110 U	NS	NS	NS	NS	100 U	NS	NS
Aroclor-1254	200 U	NS	NS	NS	NS	210 U	210 U	NS	NS	NS	NS	200 U	NS	NS
Aroclor-1260	220	NS	NS	NS	NS	210 U	210 U	NS	NS	NS	NS	200 U	NS	NS
RADIOACTIVITY														
Gross Alpha Screen	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gross Beta Screen	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected July 4-8, 1991
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment Sample (i.e., SD06E)
F - Duplicate Sediment Sample (i.e., SD06F)

TABLE 4-3

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs) AND RADIOACTIVITY IN SEDIMENT[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PESTICIDES [a]													
α-BHC	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
β-BHC	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
δ-BHC	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
γ-BHC (Lindane)	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
Heptachlor	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
Aldrin	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
Heptachlor Epoxide	NS	NS	11 R	NS	NS	NS	11 U	11 R	NS	NS	NS	NS	NS
Endosulfan I	NS	NS	11 U	NS	NS	NS	11 U	11 U	NS	NS	NS	NS	NS
Dieldrin	NS	NS	21 U	NS	NS	NS	22 U	22 U	NS	NS	NS	NS	NS
4,4'-DDE	NS	NS	21 U	NS	NS	NS	22 U	22 U	NS	NS	NS	NS	NS
Endrin	NS	NS	21 UJ	NS	NS	NS	22 U	22 UJ	NS	NS	NS	NS	NS
Endosulfan II	NS	NS	21 U	NS	NS	NS	22 U	22 U	NS	NS	NS	NS	NS
4,4'-DDD	NS	NS	21 U	NS	NS	NS	22 U	22 U	NS	NS	NS	NS	NS
Endosulfan Sulfate	NS	NS	21 UJ	NS	NS	NS	22 U	22 UJ	NS	NS	NS	NS	NS
4,4'-DDT	NS	NS	21 U	NS	NS	NS	22 U	22 U	NS	NS	NS	NS	NS
Methoxychlor	NS	NS	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Endrin Ketone	NS	NS	21 U	NS	NS	NS	22 U	22 U	NS	NS	NS	NS	NS
α-Chlordane	NS	NS	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
δ-Chlordane	NS	NS	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Toxaphene	NS	NS	210 U	NS	NS	NS	220 U	220 U	NS	NS	NS	NS	NS

Data Qualifier Legend
(a) - EPA SW8080 compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
E - Sediment Sample (i.e., SD06E)
F - Duplicate Sediment Sample (i.e., SD06F)

TABLE 4-3

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs) AND RADIOACTIVITY IN SEDIMENT(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD26E	SD22E	SD23E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
POLYCHLORINATED BIPHENYLS (PCBs) (a)													
Arclor-1016	NS	0.50 U	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Arclor-1221	NS	0.50 U	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Arclor-1232	NS	0.50 U	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Arclor-1242	NS	0.50 U	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Arclor-1248	NS	0.50 U	110 U	NS	NS	NS	110 U	110 U	NS	NS	NS	NS	NS
Arclor-1254	NS	1.0 U	210 U	NS	NS	NS	220 U	220 U	NS	NS	NS	NS	NS
Arclor-1260	NS	1.0 U	210 U	NS	NS	NS	220 U	220 U	NS	NS	NS	NS	NS
RADIOACTIVITY													
Gross Alpha Screen	NS	1.0 U	4.0 +/-2.8	NS	NS	NS	NS	9.2 +/-3.7	NS	NS	NS	NS	NS
Gross Beta Screen	NS	1.0 U	16 +/-4	NS	NS	NS	NS	7.7 +/-3.8	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected July 4–8, 1991
J - The associated numerical value is an estimated quantity
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment Sample (i.e., SD06E)
F - Duplicate Sediment Sample (i.e., SD06F)

TABLE 4-4

CONTAMINANT INDICATOR COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek									
Sample Number	SD01E	SD02E	SD03E	SD04E	SD05E	SD06E	SD06F	SD07E	SD07F	SD08E	SD09E	SD10E	SD11E	SD12E	SD13E
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Alkalinity, Bicarbonate (as CaC03)	160	170	150	210	130	230	260	150	200	240	210	180	220	190	300
Alkalinity, Carbonate (as CaC03)	0	0	0	0	0	0	0	0	0	0	0	0	<10	0	0
Alkalinity, Total (as CaC03)	160	170	150	210	130	230	260	150	200	240	210	180	220	190	300
Carbon, Total Organic (C)	1100 J	630 J	610 J	2500 J	1100 J	1300 J	1600 J	2300 J	1300 J	1300 J	1100 J	2700 J	1400 J	1300 J	3700 J
Chloride (Cl)	21 J	NS	NS	NS	NS	34 J	27 J	NS	NS	NS	NS	NS	23 J	NS	NS
Fluoride, Total (F)	<500	NS	NS	NS	NS	<600	<600	NS	NS	NS	NS	NS	<400	NS	NS
Halogens, Total Organic (TOX)	NS	21 J	32 J	<20 UJ	<20 UJ	NS	NS	<20 UJ	<20 UJ	<20 UJ	<20 UJ	<20 UJ	NS	<20 UJ	<20 UJ
Nitrate (as N)	3.5	NS	NS	NS	NS	1.6	<0.5	NS	NS	NS	NS	NS	<0.5	NS	NS
pH (b)	7.9	7.6	8.1	7.6	7.8	7.7	7.6	7.7	7.7	7.7	7.9	7.9	7.8	8.0	7.9
Phenolics	NS	1.7	3	2.4	2.0	NS	NS	2.9	3.2	3.2	3.8	4.0	NS	2.1	4.9
Phosphorus, Total (as P)	11 J	NS	NS	NS	NS	57 J	6 J	NS	NS	NS	NS	NS	21 J	NS	NS
Sulfate (as S04)	32	NS	NS	NS	NS	47	34	NS	NS	NS	NS	NS	30	NS	NS

Data Qualifier Legend

(a) - Samples collected July 4–8, 1991.
(b) - pH is dimensionless.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-4

CONTAMINANT INDICATOR COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Crutcho Creek											Elm Creek		
Sample Number	SD14E	SD15E	SD16E	SD17E	SD18E	SD19E	SD20E	SD21E	SD25E	SD25F	SD26E	SD22E	SD23E	SD24E
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Alkalinity, Bicarbonate (as CaC03)	140	290	260	250	260	190	300	300	260	260	300	210	280	180
Alkalinity, Carbonate (as CaC03)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alkalinity, Total (as CaC03)	140	290	260	250	260	190	300	300	260	260	300	210	280	180
Carbon, Total Organic (C)	720 J	1000 J	480 J	1400 J	1100 J	1900 J	NS	1200 J	1900 J	2000 J	1500 J	2100 J	6400 J	1900 J
Chloride (Cl)	NS	NS	26 J	NS	NS	NS	38 J	NS	NS	NS	NS	21 J	NS	NS
Fluoride, Total (F)	NS	NS	<600	NS	NS	NS	<600	NS	NS	NS	NS	<600	NS	NS
Halogens, Total Organic (EOX)	<20 UJ	<20 UJ	NS	<20 UJ	<20 UJ	<20 UJ	NS	<20 UJ	<20 UJ	<20 UJ	<20 UJ		<20 UJ	<20 UJ
Nitrate (as N)	NS	NS	<0.5	NS	NS	NS	<0.5	NS	NS	NS	NS	1.8	NS	NS
pH (b)	7.9	7.8	7.8	7.9	8.0	7.7	7.7	7.9	8.0	8.0	7.9	7.9	8.0	7.9
Phenolics	2.5	3.3	NS	<1.1	2.1	1.1	NS	1.2	2.0	15	1.5		2.0	5.0
Phosphorus, Total (as P)	NS	NS	6 J	NS	NS	NS	52 J	NS	NS	NS	NS	36 J	NS	NS
Sulfate (as S04)	NS	NS	26	NS	NS	NS	30	NS	NS	NS	NS	44	NS	NS

Data Qualifier Legend
(a) - Samples collected July 4–8, 1991
(b) - pH is dimensionless
J - The associated numerical value is an estimated quantity.
NS - Not sampled
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
E - Sediment sample (i.e., SD01E)
F - Duplicate sediment sample (i.e., SD06F)

TABLE 4-5

INORGANICS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Antimony	6.0 U	6.0 U	6.0 U	6.0 UJ	3.0 UJ	6.0 UJ	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	3.0 UJ	3.0 UJ	NS
Arsenic	2.4 J	2.2	2.0 U	2.8	2.0 UJ	2.8	2.7 J	2.6	2.8	2.4	2.3	2.0 UJ	2.0 UJ	NS
Barium	449 J	448 J	369 J	343 J	393 J	450 J	447 J	469 J	553 J	642 J	508 J	469 J	533 J	NS
Beryllium	1.7 U	1.9 U	1.9 U	1.7 U	2.4 U	2.1 U	1.8 U	1.9 U	1.6 U	1.5 U	2.1 U	3.4 U	3.3 U	NS
Cadmium	3.0 U	3.0 U	3.0 U	3.0 U	4.2 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	4.0 U	NS
Calcium	38400	33300	36800	43100	50700 J	36300	35500	36500	42700	60100	40200	56400 J	55000 J	NS
Chromium	8.0 U	5.8 U	5.4 U	6.4 U	5.0 UJ	5.0 U	7.7 U	6.0 U	5.0 U	5.0 U	5.7 U	5.0 UJ	5.0 UJ	NS
Cobalt	11.1	9.9	9.0 U	16.2	16.3 U	12.1	9.0 U	9.0 U	9.3	9.0 U	12.3	15.9 U	13.3 U	NS
Copper	10.0 U	10.0 U	10.0 U	10.0 U	12.2	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	NS
Cyanide	10.0 U	NS	NS	NS	NS	10.0 U	10.0 U	NS	NS	NS	NS	NS	NS	NS
Lead	4.4 J	5.9 J	7.5 J	3.2 J	1.2	8.2 J	6.2 J	3.1 J	2.6 J	1.2 J	3.1 J	2.6	1.8	NS
Magnesium	13900	10200	25100	11300	22900	15900	16400	16100	20900	21700	18600	18800	26500	NS
Mercury	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NS
Nickel	32.1 U	16.0 U	28.4 U	22.3 U	16.0 U	27.2 U	22.7 U	28.4 U	23.5 U	33.4 U	17.2 U	16.0 U	16.0 U	NS
Selenium	1.0 U	1.0 U	1.0 U	1.0 U	1.1 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 UJ	NS
Silver	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.0 R	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	6.0 R	5.0 R	NS
Sodium	20400	9230	57300	23600	44900	32100	31200	36200	43900	43100	51500	36100	64500	NS
Thallium	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NS
Vanadium	9.0 UJ	9.0 UJ	9.0 UJ	9.0 UJ	50.0 U	9.0 UJ	9.0 UJ	9.0 UJ	9.0 UJ	9.0 UJ	9.0 UJ	45.0 U	40.0 U	NS
Zinc	28.9 U	21.8 U	17.1 U	20.1 U	6.0 UJ	17.3 U	16.1 U	12.8 U	11.3 U	9.3 U	11.6 U	6.0 UJ	6.0 UJ	NS

Data Qualifier Legend
(a) - Samples collected July 4-8, 1991.
(b) - Sample collected from standing pool of water.
J - The associated numerical value is an estimated quantity
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-5

INORGANICS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Crutcho Creek											Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW20C	SW21W	SW25W	SW26W[b]	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Antimony	6.0 U	3.0 UJ	3.0 UJ	3.0 UJ	3.0 UJ	3.0 UJ	3.0 UJ	3.0 UJ	3.0 UJ	NS	3.0 UJ	6.0 UJ	NS	NS
Arsenic	2.0 U	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	2.0 UJ	NS	2.0 UJ	2.0 U	NS	NS
Barium	539 J	692 J	833 J	547 J	394 J	742 J	425 J	416 J	340 J	NS	297 J	251 J	NS	NS
Beryllium	1.6 U	2.9 U	3.6 U	3.4 U	3.5 U	2.6 U	3.7 U	2.2 U	3.2 U	NS	2.9 U	1.2 U	NS	NS
Cadmium	3.0 U	4.7 U	3.4 U	3.9 U	3.0 U	4.0 U	4.5 U	4.3 U	3.5 U	NS	4.0 U	3.0 U	NS	NS
Calcium	44600	60100 J	67000 J	50600 J	43100 J	45200 J	70000 J	73800 J	42500 J	NS	NS	22200	NS	NS
Chromium	6.6 U	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.1 J	5.0 UJ	5.0 UJ	5.0 UJ	NS	5.0 UJ	5.7 U	NS	NS
Cobalt	12.1	19.8 U	14.2 U	16.4 U	16.1 U	13.0 U	12.6 U	16.4 U	14.5 U	NS	10.6 U	16.0	NS	NS
Copper	10.0 U	10.0 U	10.0 U	10.0 U	11.7	10.0 U	10.0 U	10.0 U	11.0	NS	10.0 U	10.0 U	NS	NS
Cyanide	NS	NS	10.0 U	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lead	3.7 J	2.8	2.6	2.6	3.2	1.4	1.0 U	1.0 U	2.3	NS	1.0 U	3.5 J	NS	NS
Magnesium	20500	30600	35900	27900	13800	26400	52100	53500	26600	NS	30100	7920	NS	NS
Mercury	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NS	0.10 U	0.10 U	NS	NS
Nickel	25.9 U	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	NS	16.0 U	20.8 U	NS	NS
Selenium	1.4	1.0 UJ	1.0 UJ	1.0 U	1.0 U	1.0 U	1.2 U	1.9 U	1.0 UJ	NS	1.0 UJ	1.0 U	NS	NS
Silver	5.0 UJ	5.0 R	5.0 R	5.0 R	6.0 R	5.0 R	5.0 R	5.0 R	5.0 R	NS	5.0 R	5.0 UJ	NS	NS
Sodium	30200	39400	43900	42000	19100	41500	113000	112000	42200	NS	NS	2800	NS	NS
Thallium	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NS	2.0 U	2.0 U	NS	NS
Vanadium	9.0 UJ	46.0 U	41.0 U	42.0 U	44.0 U	42.0 U	40.0 U	45.0 U	45.0 U	NS	40.0 U	9.0 UJ	NS	NS
Zinc	12.3 U	6.2 J	6.0 UJ	6.0 UJ	26.5 J	6.0 UJ	24.4 J	33.0 J	6.0 UJ	NS	17.3 J	18.6 U	NS	NS

Data Qualifier Legend

(a) - Samples collected July 4-8, 1991
(b) - Sample collected from standing pool of water.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
N-Nitrosodimethylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Phenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Aniline	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
bis(2-Chloroethyl)ether	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Chlorophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,3-Dichlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,4-Dichlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Benzyl alcohol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,2-Dichlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Methylphenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
bis(2-Chloroisopropyl)ether	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Methylphenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitroso-Di-n-propylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Hexachloroethane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Nitrobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Isophorone	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Nitrophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,4-Dimethylphenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
bis(2-Chloroethoxy)Methane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,4-Dichlorophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,2,4-Trichlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Naphthalene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Chloroaniline	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Hexachlorobutadiene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity
NS - Not Sampled.
R - Data rejected (Note: Analyte may or may not be present)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW011W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
4-Chloro-3-Methylphenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Methylnaphthalene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Hexachlorocyclopentadien	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,4,6-Trichlorophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,4,5-Trichlorophenol	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
2-Chloronaphthalene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Nitroaniline	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Dimethyl phthalate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Acenaphthylene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,6-Dinitrotoluene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
3-Nitroaniline	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Acenaphthene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,4-Dinitrophenol	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
4-Nitrophenol	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Dibenzofuran	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,4-Dinitrotoluene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Diethylphthalate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Chlorophenyl phenyl ether	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Fluorene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Nitroaniline	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
4,6-Dinitro-2-Methyl Phenol	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
N-Nitrosodiphenylamine(1)	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Bromophenyl -phenyl ether	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Hexachlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Pentachlorophenol	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Phenanthrene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Anthracene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Di-n-butyl phthalate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Fluoranthene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Pyrene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Butylbenzyl phthalate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
3,3'Dichlorobenzidine	20 U	NS	NS	NS	20 U	20 U	20 U	NS	NS	NS	NS	20 U	NS	NS
Benzo(a)anthracene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Chrysene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
bis(2-Ethylhexyl)phthalate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Di-n-octyl phthalate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Benzo(b)fluoranthene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Benzo(k)fluoranthene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Benzo(a)pyrene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Indeno(1,2,3-cd)pyrene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Dibenzo(a,h)anthracene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Benzo(g,h,i) Perylene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,3,4,6-Tetrachlorophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Pyridine, 2-MethyL(2-Picolin)	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Methanesulfonic Acid Ethyl	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitrosopiperidine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2,6-Dichlorophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitroso Di-n-butylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Methanesulfonic Acid, Methyl	10 UJ	NS	NS	NS	10 UJ	10 UJ	10 UJ	NS	NS	NS	NS	10 UJ	NS	NS

Data Qualifier Legend

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Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Acetophenone	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
A,A-Dimethylphenethylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Pentachlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Aminobiphenyl	10 UJ	NS	NS	NS	10 UJ	10 UJ	10 UJ	NS	NS	NS	NS	10 UJ	NS	NS
p-Dimethylamino-azobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
7,12-Dimethylbenzo(a) anthracene	10 UJ	NS	NS	NS	10 UJ	10 UJ	10 UJ	NS	NS	NS	NS	10 UJ	NS	NS
1,2,4,5-Tetrachlorobenzene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Diphenylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Phenacetin	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
3-Methylcholanthrene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Pronamide	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,4-Benzenediamine	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Isosafrole	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Napthaleneamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
5-Nitro-o-toluidine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
4-Nitroquinoline 1-oxide	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Methapyrilene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
2-Acetylaminofluorene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitrosomethylethylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitrosodiethylamine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitrosopyrrolidine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
N-Nitrosomorpholine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
o-Toluidine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS

Data Qualifier Legend

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Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FIVE

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03EW	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
0,0,0-Triethyl - phosphorthioat	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Pentachloronitrobenzene	50 UJ	NS	NS	NS	50 U	50 UJ	50 UJ	NS	NS	NS	NS	50 U	NS	NS
Safrole	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,4-Naphthoquinone	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
1,3,5-Trinitrobenzene	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Hexachloropropene	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
1,3-Dinitrobenzene	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
3,3'-Dimethylbenzidine	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Hexachlorophene	50 U	NS	NS	NS	50 U	50 U	50 U	NS	NS	NS	NS	50 U	NS	NS
Dimethoate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	50 U	NS	NS
Diallate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Pyridine	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
Aramite	50 UJ	NS	NS	NS	50 UJ	50 UJ	50 UJ	NS	NS	NS	NS	10 U	NS	NS
2-Secbutyl-4,6-Dinitrophenol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	50 UJ	NS	NS
M-Cresol	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS	NS	NS	10 U	NS	NS
												10 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
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NS - Not Sampled.
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Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE SIX

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
N-Nitrosodimethylamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Phenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Aniline	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
bis(2-Chloroethyl)ether	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Chlorophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,3-Dichlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,4-Dichlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Benzyl alcohol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,2-Dichlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Methylphenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
bis(2-Chloroisopropyl)ether	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Methylphenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitroso-Di-n-propylamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Hexachloroethane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Nitrobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Isophorone	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Nitrophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,4-Dimethylphenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
bis(2-Chloroethoxy) Methane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,4-Dichlorophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,2,4-Trichlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Naphthalene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Chloroaniline	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Hexachlorobutadiene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
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Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE SEVEN

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
4-Chloro-3-Methylphenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Methylnaphthalene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Hexachlorocyclopentadien	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,4,6-Trichlorophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,4,5-Trichlorophenol	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
2-Chloronaphthalene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Nitroaniline	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Dimethyl phthalate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Acenaphthylene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,6-Dinitrotoluene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
3-Nitroaniline	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Acenaphthene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,4-Dinitrophenol	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
4-Nitrophenol	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Dibenzofuran	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,4-Dinitrotoluene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Diethylphthalate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Chlorophenyl phenyl ether	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Fluorene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Nitroaniline	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
4,6-Dinitro-2-Methyl Phenol	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
N-Nitrosodiphenylamine(1)	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Bromophenyl-phenyl ether	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE EIGHT

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Hexachlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Pentachlorophenol	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Phenanthrene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Anthracene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Di-n-butyl phthalate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Fluoranthene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Pyrene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Butylbenzyl phthalate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
3,3'Dichlorobenzidine	NS	NS	20 U	NS	NS	NS	NS	20 U	NS	NS	NS	NS	NS
Benzo(a)anthracene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Chrysene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
bis(2-Ethylhexyl)phthalate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Di-n-octyl phthalate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Benzo(b)fluoranthene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Benzo(k)fluoranthene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Benzo(a)pyrene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Indeno(1,2,3-cd)pyrene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Dibenzo(a,h)anthracene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Benzo(g,h,i) Perylene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,3,4,6-Tetrachlorophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Pyridine, 2-MethyL(2-Picolin)	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Methanesulfonic Acid Ethyl	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitrosopiperidine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2,6-Dichlorophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitroso Di-n-butylamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Methanesulfonic Acid, Methyl	NS	NS	10 UJ	NS	NS	NS	NS	10 UJ	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANICS COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE NINE

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Acetophenone	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
A,A-Dimethylphenethylamin	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Pentachlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Aminobiphenyl	NS	NS	10 UJ	NS	NS	NS	NS	10 UJ	NS	NS	NS	NS	NS
p-Dimethylamino-azobenzen	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
7,12-Dimethylbenzo(a) anthracene	NS	NS	10 UJ	NS	NS	NS	NS	10 UJ	NS	NS	NS	NS	NS
1,2,4,5-Tetrachlorobenzene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Diphenylamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Phenacetin	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
3-Methylcholanthrene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Pronamide	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,4-Benzenediamine	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Isosafrole	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Napthaleneamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
5-Nitro-o-toluidine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
4-Nitroquinoline 1-oxide	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Methapyrilene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
2-Acetylaminofluorene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitrosomethylethylamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitrosodiethylamine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitrosopyrrolidine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
N-Nitrosomorpholine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
o-Toluidine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-6

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TEN

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
0,0,0-Triethyl-phosporthioat	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Pentachloronitrobenzene	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Safrole	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,4-Naphthoquinone	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
1,3,5-Trinitrobenzene	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Hexachloropropene	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
1,3-Dinitrobenzene	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
3,3'-Dimethylbenzidine	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Hexachlorophene	NS	NS	50 U	NS	NS	NS	NS	50 U	NS	NS	NS	NS	NS
Dimethoate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Diallate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Pyridine	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
Aramite	NS	NS	50 UJ	NS	NS	NS	NS	50 UJ	NS	NS	NS	NS	NS
2-Secbutyl-4,6-Dinitrophenol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS
M-Cresol	NS	NS	10 U	NS	NS	NS	NS	10 U	NS	NS	NS	NS	NS

Data Qualifier Legend
(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

SampleLocation	Kuhlman Creek					Crutcho Creek			
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
Chloromethane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Bromomethane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Vinyl Chloride	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Chloroethane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Methylene Chloride	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Acetone	10 UJ	NS	NS	NS	10 UJ	10 UJ	10 UJ	NS	NS
Carbon Disulfide	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,1-Dichloroethene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,1-Dichloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,2-Dichloroethene (total)	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Chloroform	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,2-Dichloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
2-Butanone	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
1,1,1-Trichloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Carbon Tetrachloride	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Vinyl Acetate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Bromodichloromethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek			
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
1,2-Dichloropropane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
cis-1,3-Dichloropropene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Trichloroethene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Dibromochloromethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,1,2-Trichloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Benzene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
trans-1,3-Dichloropropene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Bromoform	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
4-Methyl-2-pentanone	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
2-Hexanone	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Tetrachloroethene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Toluene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,1,2,2-Tetrachloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Chlorobenzene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Ethylbenzene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Styrene	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Xylene (total)	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Sample Location	Kuhlman Creek					Crutcho Creek			
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
Arolein	100 U	NS	NS	NS	100 U	100 U	100 U	NS	NS
Acrylonitrile	100 U	NS	NS	NS	100 U	100 U	100 U	NS	NS
2-Napthaleneamine	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Dichlorodifluoromethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Iodomethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Dibromomethane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Ethyl Methacrylate	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,2,3-Trichloropropane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,4-Dichloro-2-butene	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
AllyL Chloride	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Propionitrile	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
Methacrylonitrile	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Methylmethacrylate	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS
1,2-Dibromoethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,1,1,2-Tetrachloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
Pentachloroethane	5 U	NS	NS	NS	5 U	5 U	5 U	NS	NS
1,2-Dibromo-3-chloropropane	10 U	NS	NS	NS	10 U	10 U	10 U	NS	NS

Data Qualifier Legend

(a) - RCRA Appenix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected abovethe associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Sample Location	Crutcho Creek								
Sample Number	SW09W	SW10W	SW011W	SW12W	SW13W	SW14W	SW15W	SW016W	SW17W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
Chloromethane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Bromomethane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Vinyl Chloride	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Chloroethane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Methylene Chloride	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Acetone	NS	NS	10 UJ	NS	NS	NS	NS	10 UJ	NS
Carbon Disulfide	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,1-Dichloroethene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,1-Dichloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,2-Dichloroethene (total)	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Chloroform	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,2-Dichloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
2-Butanone	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
1,1,1-Trichloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Carbon Tetrachloride	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Vinyl Acetate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Bromodichloromethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FIVE

Sample Location	Crutcho Creek								
Sample Number	SW09W	SW10W	SW11W	SW12W	SW13W	SW14W	SW15W	SW16W	SW17W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
1,2-Dichloropropane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
cis-1,3-Dichloropropene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Trichloroethene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Dibromochloromethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,1,2-Trichloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Benzene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
trans-1,3-Dichloropropene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Bromoform	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
4-Methyl-2-pentanone	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
2-Hexanone	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Tetrachloroethene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Toluene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,1,2,2-Tetrachloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Chlorobenzene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Ethylbenzene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Styrene	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Xylene (total)	NS	NS	5 U	NS	NS	NS	NS	5 U	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4–8, 1991
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE SIX

Sample Location	Crutcho Creek								
Sample Number	SW09W	SW010W	SW011W	SW012W	SW013W	SW014W	SW015W	SW016W	SW017W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
Arolein	NS	NS	100 U	NS	NS	NS	NS	100 U	NS
Acrylonitrile	NS	NS	100 U	NS	NS	NS	NS	100 U	NS
2-Napthaleneamine	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Dichlorodifluoromethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Iodomethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Dibromomethane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Ethyl Methacrylate	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,2,3-Trichloropropane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
14-Dichloro-2-butene	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
AllyL Chloride	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Propionitrile	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
Methacrylonitrile	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Methylmethacrylate	NS	NS	10 U	NS	NS	NS	NS	10 U	NS
1,2-Dibromoethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
1,1,1,2-Tetrachloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
Pentachloroethane	NS	NS	5 U	NS	NS	NS	NS	5 U	NS
12-Dibromo-3-chloropropane	NS	NS	10 U	NS	NS	NS	NS	10 U	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE SEVEN

Sample Location	Crutcho Creek						Elm Creek		
Sample Number	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
Chloromethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Bromomethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Vinyl Chloride	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methylene Chloride	NS	NS	NS	NS	NS	NS	NS	NS	NS
Acetone	NS	NS	NS	NS	NS	NS	NS	NS	NS
Carbon Disulfide	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,1-Dichloroethene	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,1-Dichloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,2-Dichloroethene (total)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chloroform	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,2-Dichloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Butanone	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,1,1-Trichloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Carbon Tetrachloride	NS	NS	NS	NS	NS	NS	NS	NS	NS
Vinyl Acetate	NS	NS	NS	NS	NS	NS	NS	NS	NS
Bromodichloromethane	NS	NS	NS	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE EIGHT

Sample Location	Crutcho Creek						Elm Creek		
Sample Number	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Volatile Organic Compounds[a]									
1,2-Dichloropropane	NS	NS	NS	NS	NS	NS	NS	NS	NS
cis-1,3-Dichloropropene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Trichloroethene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dibromochloromethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,1,2-Trichloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Benzene	NS	NS	NS	NS	NS	NS	NS	NS	NS
trans-1,3-Dichloropropene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Bromoform	NS	NS	NS	NS	NS	NS	NS	NS	NS
4-Methyl-2-pentanone	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Hexanone	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tetrachloroethene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Toluene	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,1,2,2-Tetrachloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Chlorobenzene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ethylbenzene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Styrene	NS	NS	NS	NS	NS	NS	NS	NS	NS
Xylene (total)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

[a] - RCRA Appendix IX volatile organic compounds. Samples collected July 4–8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-7

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE NINE

Sample Location	Crutcho Creek						Elm Creek		
Sample Number	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ugl	ug/l	ug/l
Volatile Organic Compounds[a]									
Arolein	NS	NS	NS	NS	NS	NS	NS	NS	NS
Acrylonitrile	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Napthaleneamine	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dichlorodifluoromethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Iodomethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Dibromomethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ethyl Methacrylate	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,2,3-Trichloropropane	NS	NS	NS	NS	NS	NS	NS	NS	NS
14-Dichloro-2-butene	NS	NS	NS	NS	NS	NS	NS	NS	NS
AllyL Chloride	NS	NS	NS	NS	NS	NS	NS	NS	NS
Propionitrile	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methacrylonitrile	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methylmethacrylate	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,2-Dibromoethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
1,1,1,2-Tetrachloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pentachloroethane	NS	NS	NS	NS	NS	NS	NS	NS	NS
12-Dibromo-3-chloropropane	NS	NS	NS	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e, SW06C).

TABLE 4-8

PESTICIDES AND POLYCHLORINATED BIPHENYLS (PCBs) IN SURFACE WATER(a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PESTICIDES (a)														
α-BHC	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
β-BHC	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
δ-BHC	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
γ-BHC (Lindane)	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
Heptachlor	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
Aldrin	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
Heptachlor Epoxide	0.05 U	NS	NS	NS	NS	0.05 U	0.05 U	NS	NS	NS	NS	NS	NS	NS
Endosulfan I	0.05U	NS	NS	NS	NS	0.05U	0.05U	NS	NS	NS	NS	NS	NS	NS
Dieldrin	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
4,4'-DDE	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
Endrin	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
Endosulfan II	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
4,4'-DDD	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
Endosulfan Sulfate	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
4,4'-DDT	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
Methoxychlor	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Endrin Ketone	0.10 U	NS	NS	NS	NS	0.10 U	0.10 U	NS	NS	NS	NS	NS	NS	NS
α-Chlordane	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
δ-Chlordane	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Toxaphene	1.0 U	NS	NS	NS	NS	1.0 U	1.0 U	NS	NS	NS	NS	NS	NS	NS

Data Qualifier Legend
(a) - EPA SW8080 compounds. Samples collected from July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-8

PESTICIDES AND POLYCHLORINATED BIPHENYLS (PCBs) IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek								
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
POLYCHLORINATED BIPHENYLS (PCBs) (a)														
Aroclor-1016	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Aroclor-1221	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Aroclor-1232	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Aroclor-1242	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Aroclor-1248	0.50 U	NS	NS	NS	NS	0.50 U	0.50 U	NS	NS	NS	NS	NS	NS	NS
Aroclor-1254	1.0 U	NS	NS	NS	NS	1.0 U	1.0 U	NS	NS	NS	NS	NS	NS	NS
Aroclor-1260	1.0 U	NS	NS	NS	NS	1.0 U	1.0 U	NS	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-8

PESTICIDES AND POLYCHLORINATED BIPHENYLS (PCBs) IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PESTICIDES [a]													
α-BHC	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
β-BHC	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
δ-BHC	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
γ-BHC (Lindane)	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
Heptachlor	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
Aldrin	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
Heptachlor Epoxide	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
Endosulfan I	NS	0.050 U	NS	NS	NS	NS	NS	NS	NS	NS	0.050 U	NS	NS
Dieldrin	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
4,4'-DDE	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
Endrin	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
Endosulfan II	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
4,4'-DDD	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
Endosulfan Sulfate	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
4,4'-DDT	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
Methoxychlor	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Endrin Ketone	NS	0.10 U	NS	NS	NS	NS	NS	NS	NS	NS	0.10 U	NS	NS
α-Chlordane	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
δ-Chlordane	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Toxaphene	NS	1.0 U	NS	NS	NS	NS	NS	NS	NS	NS	1.0 U	NS	NS

Data Qualifier Legend
(a) - EPA SW8080 compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend
W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-8

PESTICIDES AND POLYCHLORINATED BIPHENYLS (PCBs) IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Sample Location	Crutcho Creek										Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
POLYCHLORINATED BIPHENYLS (PCBs) [a]													
Aroclor-1016	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Aroclor-1221	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Aroclor-1232	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Aroclor-1242	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Aroclor-1248	NS	0.50 U	NS	NS	NS	NS	NS	NS	NS	NS	0.50 U	NS	NS
Aroclor-1254	NS	1.0 U	NS	NS	NS	NS	NS	NS	NS	NS	1.0 U	NS	NS
Aroclor-1260	NS	1.0 U	NS	NS	NS	NS	NS	NS	NS	NS	1.0 U	NS	NS

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected July 4-8, 1991.
J - The associated numerical value is an estimated quantity.
NS - Not Sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-9

CONTAMINANT INDICATOR LEVELS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek									
Sample Number	SW01W	SW02W	SW03W	SW04W	SW05W	SW06W	SW06C	SW07W	SW07C	SW08W	SW09W	SW10W	SW11W	SW12W	SW13W
Units	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]
Alkalinity,Total (as CaC03)	150	110	200	150	250	150	160	170	NS	200	240	200	210	260	NS
BOD5	7.7	7.2	4.6	4.9	3.9	5.2	5.0	6.6	NS	5.1	5.0	6.9	3.4	3.0	NS
COD	53	60	12	31	16	27	26	26	NS	19	22	15	30	15	NS
Carbon, Organic - Nonpurgeable	16 J	20 J	3 J	10 J	360 J	6 J	6 J	6 J	NS	5 J	22 J	4 J	370 J	450 J	NS
Chloride (Cl)	19 J	11 J	60 J	19 J	34 J	40 J	42 J	47 J	NS	54 J	58 J	66 J	38 J	77 J	NS
Halogens, Total Organic (TOX)	NS	33 J	39 J	22 J	NS	NS	NS	28 J	32 J	31 J	28 J	19 J	NS	18 J	NS
Nitrate (as N)	1.6	0.9	2.9	2.7	1.9	0.6	0.6	0.4	NS	0.2	0.5	0.2	0.4	0.1	NS
Nitrite (as N)	0.068	0.072	0.031	0.174	0.211	0.025	0.026	0.017	NS	0.013	0.012	0.012	0.013	0.005	NS
Phenolics (Total)	NS	0.01	<0.01	<0.01	NS	NS	NS	<0.01	<0.01	<0.01	<0.01	<0.01	NS	<0.01	NS
Solids, Dissolved (180°C)	250	240	390	290	330	280	280	290	NS	340	390	350	390	420	NS
Solids, Suspended (103°C)	20	13	<10	<10	<10	36	38	29	NS	29	<20	20	<10	36	NS
Solids, Total (103°C)	290	270	370	300	360	18	310	340	NS	390	430	380	370	420	NS
Specific Conductance (25°C)	330	260	520	340	480	350	350	400	NS	490	520	480	430	600	NS
Sulfate, Turbidimetric (as S04)	23	46	31	60	18	23	26	24	NS	23	24	21	29	15	NS
Turbidity	43	40	2	37	8	35	56	36	NS	42	14	36	32	17	NS

Data Qualifier Legend

(a) - Samples collected July 4-8, 1991
(b) - Results are reported in mg/l except Specific Conductance (µmhos/cm) and Turbidity (NTU)
J - The associated numerical value is an estimated quantity
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-9

CONTAMINANT INDICATOR LEVELS IN SURFACE WATER[a]
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Crutcho Creek											Elm Creek		
Sample Number	SW14W	SW15W	SW16W	SW17W	SW18W	SW19W	SW20W	SW20C	SW21W	SW25W	SW26W	SW22W	SW23W	SW24W
Units	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]	mg/l[b]
Alkalinity, Total (as CaC03)	200	270	330	240	190	230	320	330	240	NS	NS	87	NS	NS
BOD5	6.0	3.1	2.6	3.0	5.7	3.6	2.8	2.1	4.2	NS	NS	6.0	NS	NS
COD	27	30	14	15	60	13	5	<5	<5	NS	NS	53	NS	NS
Carbon, Organic - Nonpurgeable	6 J	430 J	490 J	380 J	400 J	340 J	750 J	770 J	370 J	NS	NS	15 J	NS	NS
Chloride (Cl)	38 J	42 J	44 J	42 J	16 J	29 J	180 J	170 J	32 J	NS	NS	5 J	NS	NS
Halogens, Total Organic (TOX)	28 J	34 J	NS	25 J	29 J	59	87 J	NS	NS	NS	NS	34 J	NS	NS
Nitrate (as N)	0.4	0.6	0.6	1.1	5.3	2.6	1.3	1.3	1.9	NS	NS	0.2	NS	NS
Nitrite (as N)	0.007	0.01	0.015	0.025	0.308	0.041	0.007	0.005	0.024	NS	NS	0.006	NS	NS
Phenolics	<0.01	<0.01	NS	<0.01	<0.01	<0.01	<0.01	NS	NS	NS	NS	<0.01	NS	NS
Solids, Dissolved (180°C)	310	380	460	360	340	350	710	700	350	NS	NS	160	NS	NS
Solids, Suspended (103°C)	22	18	13	13	66	10	<10	<10	<10	NS	NS	18	NS	NS
Solids, Total (103°C)	340	380	490	360	340	340	750	770	370	NS	NS	190	NS	NS
Specific Conductance (25°C)	390	540	610	520	430	480	1100	1000	470	NS	NS	150	NS	NS
Sulfate, Turbidimetric (as S04)	29	22	28	18	18	25	65	70	27	NS	NS	19	NS	NS
Turbidity	37	27	19	37	66	15	8	8	16	NS	NS	58	NS	NS

Data Qualifier Legend
(a) - Samples collected July 4–8, 1991.
(b) - Results are reported in mg/l except Specific Conductance (µmhos/cm) and Turbidity (NTU)
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected but the associated value which is an estimate and may be inaccurate.

Sample Number Legend
W - Surface water sample (i.e., SW06W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-10

CONTAMINANT INDICATOR LEVELS IN SURFACE WATER (a)
BASELINE - OCTOBER 1991
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek	Crutcho Creek			Elm Creek	
Sample Number	SW27W	SW13W	SW13C	SW25W	SW23W	SW24W
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Alkalinity, Total (as CaCO3)	44	140	140	94	160	98
BOD5	NS	NS	NS	NS	NS	NS
COD	20	18 J	24 J	20	72	54
Carbon, Organic-Nonpurgeable	6	7	7	7	25	17
Chloride (Cl)	3	12	11	9	11	6
Halogens, Total Organic (TOX)(c)	< 10 UJ	140 J	< 10 UJ	37 J	56 J	12 J
Nitrate (as N)	0.2	NS	NS	NS	NS	NS
Nitrite (as N)	NS	NS	NS	NS	NS	NS
Phenolics (Total)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Solids, Dissolved (180 C)	110	214	221	201	280	169
Solids, Suspended (103 C)	13 J	< 10 UJ	< 10 UJ	69 J	23 J	21 J
Solids, Total (103 C)	89	214	230	262	314	189
Specific Conductance (b) (25 C)	NS	NS	NS	NS	NS	NS
Sulfate, Turbidimetric (as SO4)	8	19	19	21	24	13
Turbidity (b)	NS	NS	NS	NS	NS	NS

Data Qualifier Legend

(a) - Samples collected October 26-28, 1991.
(b) - Specific Conductance reported in microhms/cm and Turbidity in NTU.
(c) - TOX results reported in ug/l.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-11

INORGANICS IN SURFACE WATER (a)
BASELINE - OCTOBER 1991
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek	Crutcho Creek			Elm Creek	
Sample Number	SW27W	SW13W	SW13C	SW25W	SW23W	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Aluminum	NS	NS	NS	NS	NS	NS
Antimony	8.0 U	8.0 U	8.0 U	8.0 UJ	8.0 U	8.0 U
Arsenic	1.6	1.7 J	2.3 J	1.4 J	1	2.1 J
Barium	57.0 J	707 J	625 J	224 J	381 J	221 J
Beryllium	4.6 U	4.6 U	3.7 U	4.5 U	3.9 U	4.8 U
Cadmium	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ
Calcium	16000 J	33700 J	26300 J	29000 J	49900 J	25900 J
Chromium	6.0 UJ	6.0 UJ	6.0 UJ	6.0U J	6.0 UJ	6.0 UJ
Cobalt	13.0 U	13.0 U	13.0 U	13.0 U	14.4 U	13.0 U
Copper	15.0 U	15.0 U	15.0 U	15.0 U	16.3 J	15.2 J
Cyanide	NS	NS	NS	NS	NS	NS
Iron	NS	NS	NS	NS	NS	NS
Lead	5.8 J	1.0 UJ	8.3 J	5.6 J	1.0 UJ	1.6 J
Magnesium	1210	15900	15500	9510	14000	8540
Manganese	NS	NS	NS	NS	NS	NS
Mercury	0.10 U	0.10 U	0.1	0.10U	0.10 U	0.1
Nickel	26.0 U	26.0 U	26.0 U	26.0 U	26.0 U	26.0 U
Potassium	NS	NS	NS	NS	NS	NS
Selenium	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Silver	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U
Sodium	4250 U	13000	12300	8900	4560	6210
Thallium	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Vanadium	17.0 UJ	17.0 UJ	17.0 UJ	17.0 UJ	17.0 UJ	17.0 UJ
Zinc	18.4 J	5.0 UJ	5.0 UJ	12.4 J	97.1 J	13.4 J

Data Qualifier Legend

(a) - Samples collected October 26-28, 1991.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).

C - Duplicate surface water sample (i.e., SW06C)

Several of the target inorganics are considered non-toxic and do not have associated health risk criteria (e.g., MCLs, dose-related parameters). They are aluminum, calcium, iron, magnesium, potassium, and sodium. Therefore, these inorganics are not included as chemicals of concern.

Seven of the inorganics listed were detected in each sediment sample, which included arsenic, barium, chromium, copper, lead, vanadium, and zinc. Inorganics detected less frequently included antimony, beryllium, manganese, mercury, and selenium. All of these inorganics do have health risk data associated with them and will be considered as chemicals of concern for this investigation.

SVOCs were reported above laboratory detection limits in three sediment samples: SD01 on Kuhlman Creek and SD06 on Crutcho Creek, both located at the base's northern boundary; and SD11 on Crutcho Creek, located on the western base boundary line. The SD01 sample contained nine polynuclear aromatic hydrocarbons (PAH), which ranged in concentration from 230J ug/kg to 1300 ug/kg. Sediment sample SD06 contained Di-n-butyl phthalate at a concentration of 400J ug/kg and sediment sample SD11 contained bis(2-Ethylhexyl)phthalate at a level of 75J ug/kg. The analytical results are shown in Table 4-2.

Table 4-3 presents the analytical results for pesticides and PCBs. No pesticides were detected in any of the samples collected. However, one sample on Kuhlman Creek (SD01) did contain a PCB compound, Aroclor-1260, at a concentration of 220 ug/kg.

The results for miscellaneous contaminant indicators are listed in Table 4-4. TOX was detected in Kuhlman Creek sediment samples SD02 and SD03 at concentration levels of 21J mg/kg and 32J mg/kg, respectively. TOX values were below the laboratory detection limit of 20 mg/kg for the remaining samples. Phenolic compounds were detected in 21 sediment samples from Crutcho and Kuhlman Creeks, and the tributaries of Elm Creek. Detected levels ranged from 1.1 to 15 mg/kg. All remaining contaminant indicators were at low levels, except for total organic carbon (TOC), which was present in all samples. TOC values ranged between 480J and 6400J mg/kg.

4.2.2 Surface Water Sample Results

The laboratory data for inorganics in surface water samples collected in July 1991 and October 1991 are presented in Tables 4-5 and 4-11, respectively. The July and October 1991 samples were analyzed for 19 target inorganics. In addition, four of the July 1991 samples were analyzed for cyanide.

Twelve inorganics were reported above the laboratory detection limits in the July 1991 and October 1991 samples and are listed below:

Inorganic	Maximum Value (ug/l)	Sample Number[a]
Arsenic	2.8[b]	SW04, SW06, and SW08
Barium	833J[b]	SW16
Calcium	73800J[b]	SW20
Chromium	5.1J [b]	SW19
Cobalt	16.2[b]	SW04
Copper	16.3J[c]	SW23
Lead	8.3J[c]	SW13
Magnesium	53500[b]	SW20
Mercury	0.1[c]	SW13 and SW24
Selenium	1.4[b]	SW14
Sodium	113000[b]	SW20
Zinc	97.1[c]	SW23

(a) Sample location of maximum value
(b) July 1991
(c) October 1991

Each surface water sample collected in July 1991 contained barium, calcium, lead, magnesium, and sodium. Arsenic was detected in eight surface water samples and ranged in concentration from 2.2 to 2.8 ug/l. In the remaining samples, the arsenic concentration fell below the laboratory detection limit of 2 ug/l. Cobalt was reported in eight samples, with a concentration range of 9.3 ug/l to 16.2 ug/l. Copper was detected in two samples, both from Crutcho Creek. Selenium and chromium were each detected in one sample from Crutcho Creek. No inorganics were detected at levels above Federal safe drinking water MCLs.

All of the surface water samples collected in October 1991 contained arsenic, barium, calcium, and magnesium. Sodium and lead were present in all but one sample. Zinc was detected in four of the six samples and ranged in concentration from 13.4 to 97.1 ug/l. Mercury was reported at a level of 0.1 ug/l in two samples but was below the detection limit of 0.1 ug/l in the remaining three samples. Only one sample from Elm Creek contained a detected level of copper, 16.3J ug/l.

The July 1991 analytical data are respectively presented in Tables 4-6, 4-7, and 4-8 for VOCs, SVOCs, and pesticides/PCBs. None of the surface water samples contained concentrations of VOCs, SVOCs, or pesticides/PCBs above laboratory detection limits. The October 1991 samples were not analyzed for VOCs, SVOCs, or pesticides/PCBs.

Laboratory results for the July 1991 CIs are listed in Table 4-9. TOX was detected in 16 surface water samples from all 3 creeks and ranged in concentration from 18J mg/l in SW12 to 87J mg/l in SW20. All other contaminant indicators were detected at low levels.

CI results for the October 1991 samples are presented in Table 4-10. TOX was detected in four of six samples, with concentrations ranging from 12J to 140J ug/l. Phenols were below the detection limit of 0.01 mg/l. Alkalinity ranged from 44 to 160 mg/l. Total organic carbon (TOC), sulfate, and chloride were at low levels. COD values ranged between 18J and 72 mg/l.

4.3 CONFIRMATION DATA COLLECTION

In February 1992, sediment and surface water samples were collected from 11 sample locations. Six sampling locations were on Crutcho Creek. Three of these six locations (6, 11, and 15) had been previously sampled during the 1991 baseline sampling effort. Two locations, B-1 and B-2, were sampled for the first time to establish background conditions in Crutcho Creek. Location 17A was sampled instead of Location 17. On Kuhlman Creek, samples were recollected at Locations 1, 3, and 5. Location 24 on the tributaries of Elm Creek was resampled. Because of low base flow in the tributaries of Elm Creek, Location 22A was sampled instead of the original Location 22.

A second round of confirmation surface water sampling was conducted in May 1992. Surface water samples were collected from two locations of Kuhlman Creek, four locations on Crutcho Creek, and one location on the tributaries of Elm Creek. All locations had been previously sampled in July 1991 and in February 1992. Once again, the sample from the tributaries of Elm Creek had to be collected from Location 22A, instead of the original Location 22.

The analytical parameters performed on each sample per location are shown in Tables 3-3, 3-4, and 3-5. The analytical results for the February and May 1992 samples are presented in Tables 4-12 through 4-25.

TABLE 4-12
INORGANICS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Antimony	2.4 UJ	3.7 UJ	NS	4.5 UJ	NS	2.7 UJ	NS	2.1 UJ	NS	4.5 UJ	3.1 UJ	2.3 UJ	1.7 UJ
Arsenic	3.9 J	16.7 J	NS	13.0 J	NS	5.9 J	NS	6.4 J	NS	22.3 J	8.3 J	7.5 J	8.6 J
Barium	1840 J	2250 J	NS	1600 J	NS	9110 J	NS	2760 J	NS	10500 J	8690 J	2280 J	1010 J
Beryllium	1.8 U	3.1 U	NS	4.4 U	NS	3.8 U	NS	3.3 U	NS	7.6 U	5.7 U	4.0 U	2.3 U
Cadmium	4.5 J	4.1 J	NS	8.2 J	NS	4.6 J	NS	5.3 J	NS	5.9 J	5.4 J	1.6 U	1.9 J
Chromium	39.4	69	NS	85.4	NS	64.3	NS	408	NS	122	59.5	60.3	53.2
Cobalt	14.4 U	26.5 U	NS	20.1 U	NS	40.4 U	NS	33.7 U	NS	84.6 U	85.3 U	50.7 U	21.8 U
Copper	20.2 J	30.4 J	NS	73.8 J	NS	20.2 J	NS	30.3 J	NS	61.9 J	42.4 J	22.4 J	14.2 J
Cyanide	0.67 U	0.60 U	NS	NA	NS	0.64 U	NS	NA	NS	0.67 U	0.59 U	0.67 U	0.75 U
Lead	51.1 J	114 J	NS	106 J	NS	28.2 J	NS	62.2 J	NS	73.5 J	93.0 J	44.4 J	18.7 J
Mercury	1.8 J	3.5 J	NS	0.38 UJ	NS	0.22 UJ	NS	0.98 J	NS	0.36 UJ	0.24 UJ	0.19 UJ	0.14 UJ
Nickel	26.5 U	56.4 U	NS	55.5 U	NS	37.7 U	NS	37.1 U	NS	102 U	87.4 U	47.8 U	30.2 U
Selenium	0.40 UJ	1.2 UJ	NS	1.5 UJ	NS	0.89 UJ	NS	0.35 UJ	NS	0.75 UJ	1.0 UJ	0.39 UJ	0.29 UJ
Silver	3.6 U	5.4 U	NS	6.7 U	NS	4.0 U	NS	3.1 U	NS	6.7 U	4.6 U	3.5 U	2.6 U
Thallium	0.79 U	1.2 U	NS	1.5 U	NS	0.89 U	NS	0.70 U	NS	1.5 U	1.0 U	0.78 U	0.57 U
Vanadium	32.1	66.2	NS	33.5	NS	75.9	NS	75	NS	211	178	107	53.1
Zinc	106	166	NS	215	NS	64.3	NS	99	NS	256	123	87.9	121

Data Qualifier Legend
(a) - Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.
NA - Not analyzed.

Sample Number Legend
E - Sediment sample (i.e., SD01E).
F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-13
SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
N-Nitrosodimethylamine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Phenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Aniline	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
bis(2-Chloroethyl)ether	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2-Chlorophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
1,3-Dichlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
1,4-Dichlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Benzyl alcohol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
1,2-Dichlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2-Methylphenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
bis(2-Chloroisopropyl)ether	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
4-Methylphenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
N-Nitroso-Di-n-propylamine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Hexachloroethane	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Nitrobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Isophorone	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2-Nitrophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,4-Dimethylphenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
bis(2-Chloroethoxy)Methane	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,4-Dichlorophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
1,2,4-Trichlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Naphthalene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
4-Chloroaniline	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Hexachlorobutadiene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).

F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-13
SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
4-Chloro-3-Methylphenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2-Methylnaphthalene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Hexachlorocyclopentadien	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,4,6-Trichlorophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,4,5-Trichlorophenol	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
2-Chloronaphthalene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2-Nitroaniline	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
Dimethyl phthalate	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Acenaphthylene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,6-Dinitrotoluene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
3-Nitroaniline	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
Acenaphthene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,4-Dinitrophenol	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
4-Nitrophenol	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
Dibenzofuran	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,4-Dinitrotoluene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Diethylphthalate	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
4-Chlorophenyl phenyl ether	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Fluorene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
4-Nitroaniline	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
4,6-Dinitro-2-Methyl Phenol	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
N-Nitrosodiphenylamine(1)	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
4-Bromophenyl-phenyl ether	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).

F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-13
SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Hexachlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Pentachlorophenol	2100 U	1900 U	NS	1800 U	NS	2100 U	NS	2200 U	NS	2200 U	2000 U	2100 U	2500 U
Phenanthrene	240 J	150 J	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Anthracene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Di-n-butyl phthalate	440 U	390 U	NS	65 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Fluoranthene	380 J	180 J	NS	160 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Pyrene	400 J	160 J	NS	210 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Butylbenzyl phthalate	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
3,3-Dichlorobenzidine	880 U	790 U	NS	760 U	NS	850 U	NS	920 U	NS	920 U	820 U	880 U	1000 U
Benzo(a)anthracene	180 J	68 J	NS	90 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Chrysene	300 J	69 J	NS	110 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
bis(2-Ethylhexyl)phthalate	120 J	390 U	NS	120 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Di-n-octyl phthalate	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Benzo(b)fluoranthene	300 J	93 J	NS	160 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Benzo(k)fluoranthene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Benzo(a)pyrene	140 J	390 U	NS	72 J	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Indeno(1,2,3-cd)pyrene	110 J	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Dibenzo(a,h)anthracene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Benzo(g,h,i)Perylene	120 J	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2,3,4,6-Tetrachlorophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
PyrAdine, 2-Methyl(2-Picolin)	890 U	800 U	NS	770 U	NS	860 U	NS	930 U	NS	930 U	830 U	890 U	1000 U
Methanesulfonic Acid Ethyl	890 U	800 U	NS	770 U	NS	860 U	NS	930 U	NS	930 U	830 U	890 U	1000 U
N-Nitrosopiperidine	890 U	800 U	NS	770 U	NS	860 U	NS	930 U	NS	930 U	830 U	890 U	1000 U
2,6-Dichlorophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
N-Nitroso-Di-n-butylamine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).

F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-13
SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Methanesulfonic Acid, Methyl	2300 U	2000 U	NS	2000 U	NS	2200 U	NS	2400 U	NS	2400 U	2100 U	2300 U	2600 U
Acetophenone	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
A,A-Dimethylphenethylamine	2300 U	2000 UJ	NS	2000 U	NS	2200 U	NS	2400 U	NS	2400 U	2100 U	2300 U	2600 U
Pentachlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
4-Aminobiphenyl	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
p-Dimethylamino-azobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
7,12-Dimethylbenzo(a)anthracene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
1,2,4,5-Tetrachlorobenzene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Diphenylamine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Phenacetin	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
3-Methylcholanthrene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Pronamide	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
2-Napthaleneamine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
P-Phenylenediamine	2300 U	2000 U	NS	2000 U	NS	2200 U	NS	2400 U	NS	2400 U	2100 U	2300 U	2600 U
Isosafrole	440 U	390 U	NS	380 U	NS	420 UJ	NS	460 UJ	NS	460 U	410 U	440 U	510 U
5-Nitro-o-toluidine	890 U	800 U	NS	770 U	NS	860 U	NS	930 U	NS	930 U	830 U	890 U	1000 U
4-Nitroquinoline 1-oxide	R	R	NS	R	NS	R	NS	R	NS	R	R	R	R
Methapyrilene	440 UJ	390 UJ	NS	380 UJ	NS	420 U	NS	460 U	NS	460 UJ	410 UJ	440 U	510 UJ
2-Acetylaminofluorene	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
N-Nitrosomethylethylamine	440 U	390 UJ	NS	380 UJ	NS	420 U	NS	460 U	NS	460 UJ	410 UJ	440 U	510 UJ
N-Nitrosodiethylamine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
N-Nitrosopyrrolidine	890 U	800 UJ	NS	770 UJ	NS	860 U	NS	930 U	NS	930 UJ	830 UJ	890 U	1000 UJ
N-Nitrosomorpholine	440 U	390 UJ	NS	380 UJ	NS	420 U	NS	460 U	NS	460 UJ	410 UJ	440 U	510 UJ
O-Toluidine	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).

F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-13
SEMIVOLATILE ORGANIC COMPOUNDS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FIVE

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
0,0,0-Triethylphosphorthioat	2300 U	2000 U	NS	2000 U	NS	2200 U	NS	2400 U	NS	2400 U	2100 U	2300 U	2600 U
Safrole	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
1,4-Naphthoquinone	440 UJ	390 UJ	NS	380 UJ	NS	420 UJ	NS	460 UJ	NS	460 UJ	410 UJ	440 UJ	510 UJ
1,3,5-Trinitrobenzene	2300 U	2000 U	NS	2000 UJ	NS	2200 U	NS	2400 U	NS	2400 UJ	2100 UJ	2300 UJ	2600 UJ
Hexachloropropene	R	R	NS	R	NS	R	NS	R	NS	R	R	R	R
1,3-Dinitrobenzene	2300 U	2000 U	NS	2000 U	NS	2200 UJ	NS	2400 UJ	NS	2400 U	2100 U	2300 U	2600 U
3,3-Dimethylbenzidine	R	R	NS	R	NS	R	NS	R	NS	R	R	R	R
Hexachlorophene	4400 U	3900 U	NS	3800 U	NS	4200 U	NS	4600 U	NS	4600 U	4100 U	4400 U	5100 U
Dimethoate	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
Diallate	440 U	390 UJ	NS	380 UJ	NS	420 U	NS	460 U	NS	460 UJ	410 UJ	440 U	510 UJ
Pyridine	440 U	390 U	NS	380 U	NS	420 UJ	NS	460 UJ	NS	460 U	410 U	440 U	510 U
Aramite	2300 UJ	2000 UJ	NS	2000 UJ	NS	2200 U	NS	2400 U	NS	2400 UJ	2100 UJ	2300 UJ	2600 UJ
2-Secbutyl-4,6-Dinitrophenol	440 U	390 U	NS	380 U	NS	420 U	NS	460 U	NS	460 U	410 U	440 U	510 U
M-Cresol	440 U	390 U	NS	380 U	NS	420 UJ	NS	460 UJ	NS	460 U	410 U	440 U	510 U
Pentachloronitrobenzene	2300 U	2000 U	NS	2000 U	NS	2200 U	NS	2400 U	NS	2400 U	2100 U	2300 U	2600 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).

F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-14

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs), AND RADIOACTIVITY IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
PESTICIDES													
a-BHC	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
B-BHC	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
d-BHC	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
v-BHC(Lindane)	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
Heptachlor	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
Aldrin	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
Heptachlor Epoxide	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
Endosulfan 1	43 UJ	9.5 U	NS	NS	NS	10 U	NS	11 U	NS	11 U	9.9 U	11 U	12 U
Dieldrin	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
4,4'-DDE	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
Endrin	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
Endosulfan II	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
4,4'-DDD	85 UJ	19 U	NS	NS	NS	21 U	NS	18	NS	22 U	20 U	21 U	25 U
Endosulfan Sulfate	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
4,4'-DDT	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
Methoxychlor	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Endrin Ketone	85 UJ	19 U	NS	NS	NS	21 U	NS	22 U	NS	22 U	20 U	21 U	25 U
a-Chlordane	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
b-Chlordane	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Toxaphene	850 UJ	190 U	NS	NS	NS	210 U	NS	220 U	NS	220 U	200 U	210 U	250 U

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).
F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-14
PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs), AND RADIOACTIVITY IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE TWO

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
POLYCHLORINATED BIPHENYLS(PCBs)													
Aroclor-1016	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Aroclor-1221	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Aroclor-1232	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Aroclor-1242	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Aroclor-1248	430 UJ	95 U	NS	NS	NS	100 U	NS	110 U	NS	110 U	99 U	110 U	120 U
Aroclor-1254	850 UJ	190 U	NS	NS	NS	210 U	NS	220 U	NS	220 U	200 U	210 U	250 U
Aroclor-1260	120 J	160	NS	NS	NS	210 U	NS	220 U	NS	220 U	200 U	210 U	250 U
RADIOACTIVITY													
Gross Alpha Screen (b)	NS	NS	NS	NS	NS	NS	NS	< 7	< 8	9.9 +/-6.2	7.9 +/- 6	< 10	< 7
Gross Beta Screen (b)	NS	NS	NS	NS	NS	NS	NS	15 +/- 4	14 +/- 4	12 +/- 4	14 +/- 4	6.7 +/-3.8	12 +/- 4

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected February 3-10, 1992.

(b) - Units are pCi/g.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

E - Sediment sample (i.e., SD01E).

F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-15

CONTAMINANT INDICATOR LEVELS IN SEDIMENT (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek					Crutcho Creek						Elm Creek	
Sample Number	SD01E	SD01F	SD03E	SD05E	SD05F	SD06E	SD11E	SD15E	SD17A E	SDB1E	SDB2E	SD22A E	SD24E
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Alkalinity, Total (as CaCO3)	81 J	< 5 UJ	180	NA	140	< 5	160	81	< 5	160	< 5	< 5	< 5
Carbon, Total Organic (C)	240 J	1700 J	2100 J	NA	2400 J	1200J	1700 J	1400 J	530 J	3600 J	170 J	670 J	3300 J
Halogens, Total Organic (TOX)	44 J	26 J	< 20 UJ	NA	< 20 UJ	< 20 UJ	< 20 UJ	< 20 UJ	< 20 UJ	21 J	29 J	160 J	63 J
Nitrate (as N)	4 J	1.8 J	2.2	NA	1.1	1.2	1.1	1.4	1.1	18	2.1	1	1
pH (b)	7.2	7.4	7.4	7.4	7.4	6.6	7.3	7	7.5	7.3	7.9	7.7	7.3

Data Qualifier Legend

(a) - Samples collected February 3-10, 1992.
(b) - pH is dimensionless.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - The data are unusable. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.
NA - Not analyzed.

Sample Number Legend

E - Sediment sample (i.e., SD01E).
F - Duplicate sediment sample (i.e., SD06F).

TABLE 4-16
INORGANICS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek				Crutcho Creek								Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW06C	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Antimony	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	NS	NS	6.0 U	NS	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U
Arsenic	1.2	1.0 U	1.2	1.0 U	1.5	NS	NS	1.8	NS	1.3	1.1	1.2	1	1.0 U
Barium	376 J	348 J	345 J	382 J	640 J	NS	NS	623 J	NS	434 J	534 J	754 J	367 J	566 J
Beryllium	2.0 U	2.0 U	2.0 U	2.4 U	2.3 U	NS	NS	2.0 U	NS	2.9 U	2.7 U	6.5 U	2.0 J	3.6 U
Cadmium	7.1 U	4.4 U	4.2 U	7.2 U	4.0 U	NS	NS	4.0 U	NS	4.0 U	4.0 U	4.0 U	4.0 U	6.5 U
Chromium	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	NS	NS	10.0 U	NS	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
Cobalt	27.0 U	27.0 U	27.0 U	27.0 U	27.0 U	NS	NS	27.0 U	NS	27.0 U	27.0 U	27.0 U	27.0 U	27.0 U
Copper	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U	NS	NS	16.0 U	NS	16.0 U	16.0 U	16.0 U	16.0 U	16.0 U
Cyanide	10 U	10 U			10 U	NS	NS		NS		10 U	10 U	10 U	10 U
Lead	1.0 U	1.0 U	1.0 U	1	1.0 U	NS	NS	1.0 U	NS	1.0 U	1.8	1.0 U	1.0 U	1.0 U
Mercury	0.10 U	0.1 U	0.1 U	0.1 U	0.1 U	NS	NS	0.1 U	NS	0.10 U	0.1 U	0.1 U	0.1 U	0.1 U
Nickel	38.0 U	38.0 U	38.0 U	38.0 U	38.0 U	NS	NS	38.0 U	NS	38.0 U	38.0 U	38.0 U	38.0 U	38.0 U
Selenium	1.4	1.6	1.3	1.2	1	NS	NS	1.0 U	NS	1.0 U	1.2	1.2 J	1.0 U	1.0 U
Silver	9.0 U	9.0 U	9.0 U	9.0 U	9.0 U	NS	NS	9.0 U	NS	9.0 U	9.0 U	9.0 U	9.0 U	9.0 U
Thallium	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NS	NS	2.0 U	NS	2.0 UJ	2.0 U	2.0 U	2.0 U	2.0 U
Vanadium	23.0 UJ	23.0 UJ	23.0 UJ	23.0 UJ	23.0 UJ	NS	NS	23.0 UJ	NS	23.0 UJ	23.0 UJ	23.0 UJ	23.0 UJ	23.0 UJ
Zinc	7.6	12.2	101	124	6.0 U	NS	NS	8.3	NS	48.7	14.2	6.0 U	6.8	9.4

Data Qualifier Legend

(a) - Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation llimit or detection limit.
UJ - The compound was not detected above the associated value which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW01C).

TABLE 4-17

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
N-Nitrosodimethylamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Aniline	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
bis(2-Chloroethyl)ether	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Benzyl alcohol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Methylphenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
bis(2-Chloroisopropyl)ether	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
4-Methylphenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitroso-Di-n-propylamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Nitrophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
bis(2-Chloroethoxy)Methane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
4-Chloroaniline	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)

C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-17

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE TWO

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
4-Chloro-3-Methylphenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Methylnaphthalene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Hexachlorocyclopentadien	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
2-Chloronaphthalene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Nitroaniline	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Dimethyl phthalate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
3-Nitroaniline	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Acenaphthene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
4-Nitrophenol	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Dibenzofuran	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	50 UJ	50 UJ	50 U	50 UJ
2,4-Dinitrotoluene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
4-Chlorophenyl phenyl ether	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
4,6-Dinitro-2-Methyl Phenol	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
N-Nitrosodiphenylamine(1)	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
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Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-17

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE THREE

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Hexachlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Pentachlorophenol	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Phenanthrene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Anthracene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Di-n-butyl phthalate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Pyrene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Butylbenzyl phthalate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
3,3-Dichlorobenzidine	20 U	20 U	20 U	NS	20 U	NS	20 U	NS	NS	20 U	20 U	20 U	20 U
Benzo(a)anthracene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate	6 J	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Di-n-octyl phthalate	14 J	10 UJ	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
benzo(b)fluoranthene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Benzo(g,h,i)Perylene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2,3,4,6-Tetrachlorophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected February 3-10, 1992.

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Sample Number Legend

W - Surface water sample (i.e., SW01W)

C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-17

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE FOUR

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PyrAdine, 2-Methyl(2-Picolin)	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Methanesulfonic Acid Ethyl	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitrosopiperidine	20 U	20 U	20 U	NS	20 U	NS	20 U	NS	NS	20 U	20 U	20 U	20 U
2,6-Dichlorophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitroso-Di-n-butylamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Methanesulfonic Acid, Methyl	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
A,A-Dimethylphenethylamine	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ	NS	NS	10 UJ	10 UJ	10 U	10 UJ
Pentachlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
4-Aminobiphenyl	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
p-Dimethylamino-azobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
7,12-Dimethylbenzo(a)anthracene	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Diphenylamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Phenacetin	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
3-Methylcholanthrene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Pronamide	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,4-Benzenediamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
P-Phenylenediamine	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Isosafrole	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Napthaleneamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
5-Nitro-O-toluidine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
4-Nitroquionoline 1-oxide	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U

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Sample Number Legend
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C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-17

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE FIVE

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Methapyrilene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Acetylaminofluorene	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitrosomethylethylamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitrosodiethylamine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
N-Nitrosomorpholine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
o-Toluidine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
0,0,0-Triethylphosphorthioat	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Safrole	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,4-Naphthoquinone	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
1,3,5-Trinitrobenzene	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
Hexachloropropene	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
1,3-Dinitrobenzene	20 U	20 U	20 U	NS	20 U	NS	20 U	NS	NS	20 U	20 U	20 U	20 U
3,3-Dimethylbenzidine	0 U	0 U	0 U	NS	0 U	NS	0 U	NS	NS	0 U	0 U	0 U	0 U
Hexachlorophene	1000 U	1000 U	1000 U	NS	1000 U	NS	1000 U	NS	NS	1000 U	1000 U	1000 U	1000 U
Dimethoate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Diallate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Pyridine	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Aramite	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U
2-Secbutyl-4,6-Dinitrophenol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
M-Cresol	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Pentachloronitrobenzene	50 U	50 U	50 U	NS	50 U	NS	50 U	NS	NS	50 U	50 U	50 U	50 U

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UJ - The compound was not detected above the associated value, which is an estimate and

Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-18

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Chloromethane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Bromomethane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Vinyl Chloride	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Chloroethane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Methylene Chloride	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Acetone	10 UJ	10 UJ	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Carbon Disulfide	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,2-Dichloroethene(total)	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Chloroform	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
2-Butanone	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,1,1-Trichloroethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Carbon Tetrachloride	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Vinyl Acetate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Bromodichloromethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-18

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE TWO

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
1,2-Dichloropropane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Trichloroethene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Benzene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Bromoform	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	10 U	10 U	10 UJ	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
2-Hexanone	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Tetrachloroethene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Ethylbenzene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Styrene	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Xylene(total)	5 U	5 U	4 J	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U

Data Qualifier Legend
(a) - RCRA Appendix IX volatile organic compounds. Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend
W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-18

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE THREE

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Arolein	100 U	100 U	100 U	NS	100 U	NS	100 U	NS	NS	100 U	100 U	100 U	100 U
Acrylonitrile	100 U	100 U	100 U	NS	100 U	NS	100 U	NS	NS	100 U	100 U	100 U	100 U
Dichlorodifluoromethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 UJ	5 UJ	5 UJ	5 UJ
Iodomethane	5 UJ	5 UJ	5 U	NS	5 UJ	NS	5 UJ	NS	NS	5 U	5 U	5 U	5 U
Methylene Bromide	5 U	5 U	5 U	NS	5 UJ	NS	5 UJ	NS	NS	5 U	5 U	5 U	5 U
Ethyl Methacrylate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,2,3-Trichloropropane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,4-Dichloro-2-butene	5 U	5 U	5 U	NS	R	NS	R	NS	NS	5 U	5 U	5 U	5 U
Trichlorofluoromethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
AllyL Chloride	5 UJ	5 UJ	5 U	NS	5 UJ	NS	5 UJ	NS	NS	5 U	5 U	5 U	5 U
Chloroprene	0 U	0 U	0 U	NS	0 U	NS	0 U	NS	NS	0 U	0 U	0 U	0 U
Propionitrile	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Methacrylonitrile	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
Methylmethacrylate	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,2-Dibromoethane	5 U	5 U	5 U	NS	5 U	NS	5 U	NS	NS	5 U	5 U	5 U	5 U
1,1,1,2-Tetrachloroethane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
Pentachloroethane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane	10 U	10 U	10 U	NS	10 U	NS	10 U	NS	NS	10 U	10 U	10 U	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX volatile organic compounds. Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-19

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs), AND RADIOACTIVITY IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PESTICIDES													
a-BHC	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
B-BHC	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
d-BHC	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
y-BHC(Lindane)	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
Heptachlor	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
Aldrin	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
Heptachlor Epoxide	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
Endosulfan 1	0.05 U	0.05 U	NS	NS	0.05 U	NS	0.05 U	NS	NS	0.05 U	0.05 U	0.05 U	0.05 U
Dieldrin	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
4,4'-DDE	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
Endrin	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
Endosulfan II	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
4,4'-DDD	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
Endosulfan Sulfate	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
4,4' - DDT	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
Methoxychlor	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Endrin Ketone	0.10 U	0.10 U	NS	NS	0.10 U	NS	0.10 U	NS	NS	0.10 U	0.10 U	0.10 U	0.10 U
a-Chlordane	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
b-Chlordane	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Toxaphene	1.00 U	1.00 U	NS	NS	1.00 U	NS	1.00 U	NS	NS	1.00 U	1.00 U	1.00 U	1.00 U

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected February 3-10, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-19

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs), AND RADIOACTIVITY IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE TWO

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Chlorpyrifos (Dursban)	2.0 U	2.0 U	NS	NS	2.0 U	NS	2.0 U	NS	NS	2.0 U	2.0 U	2.0 U	2.0 U
Demeton	0.5 U	0.5 U	NS	NS	0.5 U	NS	0.5 U	NS	NS	0.5 U	0.5 U	0.5 U	0.5 U
Guthion	0.5 U	0.5 U	NS	NS	0.5 U	NS	0.5 U	NS	NS	0.5 U	0.5 U	0.5 U	0.5 U
Malathion	0.3 U	0.3 U	NS	NS	0.3 U	NS	0.3 U	NS	NS	0.3 U	0.3 U	0.3 U	0.3 U
Mirex	0.5 U	0.5 U	NS	NS	0.5 U	NS	0.5 U	NS	NS	0.5 U	0.5 U	0.5 U	0.5 U
Parathion	0.3 U	0.3 U	NS	NS	0.3 U	NS	0.3 U	NS	NS	0.3 U	0.3 U	0.3 U	0.3 U
POLYCHLORINATED BIPHENYLS(PCBs)													
2,4,5-TP Silvex	< 0.05	< 0.05	NS	NS	< 0.05	NS	< 0.05	NS	NS	< 0.05	< 0.05	< 0.05	< 0.05
Aroclor-1016	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1221	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1232	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1242	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1248	0.50 U	0.50 U	NS	NS	0.50 U	NS	0.50 U	NS	NS	0.50 U	0.50 U	0.50 U	0.50 U
Aroclor-1254	1.00 U	1.00 U	NS	NS	1.00 U	NS	1.00 U	NS	NS	1.00 U	1.00 U	1.00 U	1.00 U
Aroclor-1260	1.00 U	1.00 U	NS	NS	1.00 U	NS	1.00 U	NS	NS	1.00 U	1.00 U	1.00 U	1.00 U
RADIOACTIVITY													
Gross Alpha Screen (b)	< 5	4.2 +/-3.3	NS	NS	<9	NS	< 5	NS	NS	< 7	< 14	< 4	< 7
Gross Beta Screen (b)	5.3 +/-3 .4	< 5	NS	NS	6.4 +/-3.6	NS	7.2 +/-3.5	NS	NS	8.5 +/-3.6	< 13	< 5	12 +/- 3

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected February 3-10, 1992.
(b) - Units are pCi/l
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-20

CONTAMINANT INDICATOR LEVELS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek				Crutcho Creek							Elm Creek	
Sample Number	SW01W	SW01C	SW05W	SW05C	SW06W	SW11W	SW15W	SW17AW	SW20W	SWB1W	SWB2W	SW22AW	SW24W
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Alkalinity, Bicarbonate (as CaCO3)	260	260	230	240	320	320	310	240	460	450	270	260	570
BOD5	< 0.1 UJ	< 0.1 UJ	< 0.1 UJ	< 0.1 UJ	< 0.1 UJ	1.2 J	< 0.1 UJ	< 0.1 UJ	1.4 J	2.2 J	2.0 J	0.15 J	0.2 J
COD	44 J	14 J	42	23	14	9	14	14	13	32	14	12	20
Carbon, Organic-Nonpurgeable	3 J	7 J	13	2	20	6	12	9	13	8	7	4	7
Chloride(Cl)	60 J	58 J	37 J	35 J	290 J	100 J	63 J	62 J	300 J	150 J	880 J	23 J	70 J
Fluoride	1.7 J	0.3 J	0.3	0.3	0.4	0.4	0.4	0.4	1.1	0.4	0.3	0.3	0.3
Hardness, Total	230	250	210	210	380	310	310	270	580	530	540	240	570
Methane Blue Active Substances	0.0373	0.0323	NS	NS	0.031	NS	NS	NS	NS	0.015	0.035	0.068	0.0143
Nitrate (as N)	1.6	1.7	2	2	1.5	0.3	0.6	1	0.6	1.3	0.2	1.4	< 0.1
Solids, Dissolved (180 C)	390	400	330	340	700	530	450	390	1000	720	1900	310	710
Solids, Suspended (103 C)	< 10	< 10	< 10	< 10	<10	20	14	33	19	85	11	< 10	51
Turbidity	16	8	16	4	16	36	4	86	40	17	9	32	27

Data Qualifier Legend

(a) - Samples collected February 3-10, 1992.
(b) - Results for Specific Conductance are reported in microhms/cm and for Turbidity in NTU.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C)

4.3.1 Sediment Sample Results

The results of analyses for inorganics in February 1992 sediment samples are presented in Table 4-12. Samples were analyzed for 17 target inorganics. The nine inorganics reported at levels above laboratory detection limits are listed below:

Inorganic	Value[a]	Sample Number[b]
Arsenic	22.3 J	SDB1
Barium	10,500J	SDB1
Cadmium	8.2J	SD05
Chromium	408	SD15
Copper	73.8J	SD05
Lead	114J	SD01
Mercury	3.5J	SD01
Vanadium	211	SDB1
Zinc	256	SDB1

(a) Maximum values reported in mg/kg.
(b) Sample number of maximum value.

Each sediment sample collected contained arsenic, barium, chromium, copper, lead, vanadium, and zinc. Cadmium was present in all samples except SD22A from the tributaries of Elm Creek. Concentrations ranged between 1.9J and 8.2J mg/kg. Mercury was detected in one sample from Crutcho Creek (SD15, 0.98J mg/kg) and in two samples from Kuhlman Creek (SD01, 1.8J mg/kg and SD01F, 3.5J mg/kg). The maximum values for arsenic, barium, vanadium, and zinc were found in the background sample SDB1 taken from Crutcho Creek, upstream of the base.

Analytical data for SVOCs are shown in Table 4-13. SVOCs were present above laboratory detection limits only in sediment samples collected from SD01 and SD05 from Kuhlman and Crutcho Creeks, respectively, on the north base boundary. The SD01 sample and field duplicate contained 9 PAHs and 6 PAHs, respectively, at concentrations less than 500 ug/kg. Seven PAHs and one phthalate ester were detected in sample SD05 at concentrations below 250 ug/kg.

Table 4-14 presents the analyses for pesticides, PCBs, and radioactivity in sediment samples. The pesticide 4,4-DDD was detected only in one sample, SD15, from Crutcho Creek at a concentration of 18 ug/kg. Only one sample, SD01, from Kuhlman Creek contained a PCB (Aroclor-1260) at a concentration of 120J ug/kg. The duplicate sample SD01 contained the PCB at a concentration of 160 ug/kg.

The CI results for the February sediment samples are given in Table 4-15. TOC values ranged from 240J mg/kg in SD01 to 3600J mg/kg in the background sample SDB1. Half of the samples contained

TOX levels below the laboratory detection limit of 20 mg/kg. TOX levels in the remaining six samples ranged between 21 mg/kg (SDB1) and 160 mg/kg (SD22A). Nitrate was below 4 mg/kg in all samples, except for the background sample SDB1, which contained a nitrate concentration of 18 mg/kg. Average sediment pH was 7.2.

4.3.2 Surface Water Sample Results

Confirmation surface water samples were collected in February and May 1992. The analytical results of these sampling events are discussed in the following sections.

4.3.2.1 February 1992

The analytical results for inorganics in the February 1992 surface water samples are presented in Table 4-16. Of the 17 analyzed inorganics, only the 6 inorganics listed below were detected above laboratory detection limits.

Inorganic	Value[a]	Sample Number[b]
Arsenic	1.8	SW15
Barium	754J	SWB2
Beryllium [c]	2.0J	SW22A
Lead	1.8	SWB1
Selenium	1.6	SW01
Zinc	124	SW05

(a) Maximum values reported in ug/l.
(b) Sample location of maximum value.

Arsenic, barium, and zinc were common to most of the 11 surface water samples. Selenium was secondary in occurrence and was detected in seven samples. Lead was detected only in samples SW05 and SWB1. Beryllium was detected only once in sample SW22A at a low concentration of 2J. The highest concentration of barium and lead were reported in background samples SWB2 and SWB1, respectively. No inorganics were present at concentrations above Federal safe drinking water standard MCLs.

The results for the SVOCs analyses are shown in Table 4-17. SVOCs were below laboratory detection limits in all samples except SW01, which contained bis(2-Ethylhexyl)phthalate and di-n-octyl phthalate at concentrations of 6J ug/l and 14J ug/l, respectively.

Table 4-18 shows results of VOC analyses of surface water samples. Only one sample from location SW05 contained a VOC. It was identified as total xylene at a level of 4J ug/l.

The analytical data for pesticides, PCBs, and radioactivity are shown in Table 4-19. No surface water samples contained detectable amounts of pesticides, PCBs, or radioactivity.

Results for the CIs in the February surface water samples are given in Table 4-20. Alkalinity ranged from 230 to 570 mg/l. The BOD in over half of the samples was less than 0.1J mg/l. The BOD in the remaining samples ranged between 0.15J and 2.2J mg/l. Average COD ranged between 9 and 44J mg/l. TOC content averaged between 2 and 20 mg/l. The fluoride content in sediment samples did not exceed 1.7J mg/l. The chloride content was less then 100 mg/l in over half of the samples. Three samples contained chloride between 100J mg/l and 300J mg/l. The background sample SWB2 contained 880J mg/l of chloride. Water hardness ranged between 210 and 580 mg/l. Dissolved solids averaged between 300 mg/l and 1000 mg/l, with the SWB2 sample containing the maximum observed concentration of 1900 mg/l. The majority of suspended solids reported were below 35 mg/l. Two samples had suspended solids measuring 51 mg/l (SW24) and 85 mg/l (SWB1).

4.3.2.2 May 1992

The analytical results for inorganics in the May 1992 surface water samples are presented in Table 4-21. Only four samples were analyzed for inorganics, which includes SW01 from Kuhlman Creek, SW06 and SW15 from Crutcho Creek, and SW22A from the tributaries of Elm Creek. Each sample was analyzed for the 16 inorganics plus cyanide, identical to the list used to analyze the February 1992 surface water samples. Only 4 of the 16 inorganics were detected above laboratory detection limits and are shown below:

Inorganic	Value[a]	Sample Number[b]
Arsenic	2.5	SW06
Barium	1040	SW15
Vanadium	10[c]	SW22A
Zinc	11J	SW15

(a) Maximum values reported in ug/l.
(b) Sample number of maximum value.
(c) Detected in only one sample.

Arsenic was detected in three of four samples at low concentrations ranging from 1.5 to 1.7 ug/l. All four samples contained detectable levels of barium. The highest barium concentrations, 859 ug/l and 1040 ug/l, were found in samples SW06 and SW15 from Crutcho Creek, respectively. A low level of

TABLE 4-21

INORGANICS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEK AND ELM CREEK TRIBUTARIES
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Aluminum	NS	NS	NS	NS	NS	NS	NS	NS
Antimony	9 U	NS	9 U	9 U	NS	9 U	NS	9 U
Arsenic	1.50	NS	2.50	1.80	NS	1.70	NS	1 U
Barium	380.00	NS	859	850	NS	1040.00	NS	435.00
Beryllium	1 U	NS	1 U	2 U	NS	1 U	NS	1 U
Boron	NS	NS	NS	NS	NS	NS	NS	NS
Cadmium	5 UJ	NS	5 UJ	6 U	NS	5 UJ	NS	5 UJ
Calcium	NS	NS	NS	NS	NS	NS	NS	NS
Chromium	9 UJ	NS	9 UJ	9 UJ	NS	9 UJ	NS	9 UJ
Cobalt	7 U	NS	7 U	7 U	NS	7 U	NS	7 U
Copper	3 U	NS	3 U	6	NS	3 U	NS	3 U
Cyanide	10 U	NS	10 U	10 U	NS	NS	NS	10 U
Iron	NS	NS	NS	NS	NS	NS	NS	NS
Lead	2 U	NS	1.6 U	1.1 U	NS	3.1 U	NS	5.6 U
Magnesium	NS	NS	NS	NS	NS	NS	NS	NS
Manganese	NS	NS	NS	NS	NS	NS	NS	NS
Mercury	0.2 U	NS	0.2 U	0.2 U	NS	0.2 U	NS	0.2 U
Nickel	20 U	NS	20 U	20 U	NS	20 U	NS	20 U
Potassium	NS	NS	NS	NS	NS	NS	NS	NS
Selenium	2 UJ	NS	2 UJ	2 UJ	NS	2 UJ	NS	2 UJ
Silver	5 U	NS	5 U	5 U	NS	5 U	NS	5 U
Sodium	NS	NS	NS	NS	NS	NS	NS	NS
Strontium	NS	NS	NS	NS	NS	NS	NS	NS
Thallium	1 UJ	NS	1 UJ	1 UJ	NS	1 UJ	NS	1 UJ
Vanadium	6 U	NS	6 U	7	NS	6 U	NS	10.00
Zinc	5 J	NS	5 U	8 J	NS	11 J	NS	8 J

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected May 4-9, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW01C).

vanadium, 10 ug/l, was reported in sample SW22A from Elm Creek. The laboratory detection limit for this inorganic was 6 ug/l. Low concentrations of zinc were detected in three samples, ranging from 5J to 11 ug/l. Arsenic, barium, and zinc were below the current Federal safe drinking water standard MCLs. An MCL has not been established for vanadium.

The results for SVOC analyses of the five samples are presented in Table 4-22. No SVOCs were detected above laboratory detection limits in any sample. The laboratory detection limits were normal (i.e., nonelevated) compared with the February 1992 analytical analyses.

Table 4-23 presents the laboratory results from the VOC analyses of five samples. Each sample contained low concentrations of acetone and 4-Methyl-2-pentanone. Acetone concentrations ranged from 18J to 37 ug/l. The concentrations of 4-Methyl-2-pentanone ranged between 6J and 7J ug/l. These two VOCs were not present in any of the surface water samples collected in July and October 1991 or February 1992. Both VOCs are used as laboratory solvents and the absence of these VOCs in all previously collected surface water samples and their presence in all of the May 1992 samples suggests laboratory interference. All other VOCs were below laboratory detection limits.

Results for pesticide, herbicide, and PCB analyses are shown in Table 4-24. Surface water samples did not contain detectable levels of pesticides, herbicides, or PCBs, except for one sample, SW01, from Kuhlman Creek. A pesticide, chlorpyrifos (i.e., Dursban) was detected at a low concentration of 6.1 ug/l in SW01. According to base personnel, the most likely source of the Dursban is surface runoff from the B-2 storage construction site that was treated for insect control in early May 1992 by a construction subcontractor. The construction site suspected as the source of the Dursban is located in the northern part of the base and is shown in Figure 3-1. Heavy rains that occurred after the Dursban was applied are believed to have transported an unknown amount of Dursban into a tributary of Kuhlman Creek. To prevent similar construction runoff occurrences in the future, Tinker AFB has issued a policy letter to all base procurement officials and contract management offices stating that construction site runoff must be completely controlled on-site for several days after the application of any herbicide or pesticide.

The CI results for the seven surface water samples are presented in Table 4-25. Alkalinity ranged from 210 to 480 mg/l. Five of six samples had a BOD less than 0.1J mg/l. The COD ranged between 7 and 33 mg/l. Three samples had chloride concentrations from 190 mg/l to 210 mg/l. Chloride in the remaining four samples was below 70 mg/l. All seven samples contained minor amounts of fluoride. The maximum fluoride concentration of 1.2 mg/l was found in SW20 from Crutcho Creek. Water hardness ranged from 200 to 870 mg/l. Sample SW20 had the highest count of dissolved solids, 1000 mg/l. The other six samples ranged from 240 to 750 mg/l. Sample SW20 also contained the highest

TABLE 4-22

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS
AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
N-Nitrosodimethylamine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Phenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Aniline	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
bis(2-Chloroethyl)ether	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Benzyl alcohol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2-Methylphenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
bis(2-Chloroisopropyl)ether	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
4-Methylphenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
N-Nitroso-Di-n-propylamine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Isophorone	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2-Nitrophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
bis(2-Chloroethoxy)Methane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Naphthalene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
4-Chloroaniline	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected May 4-9, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)

C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-22

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE TWO

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
4-Chloro-3-Methylphenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2-Methylnaphthalene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Hexachlorocyclopentadien	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,4,5-Trichlorophenol	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2-Nitroaniline	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
Dimethyl phthalate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
3-Nitroaniline	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
Acenaphthene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,4-Dinitrophenol	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
4-Nitrophenol	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
Dibenzofuran	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
4-Chlorophenyl phenyl ether	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Fluorene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
4-Nitroaniline	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
4,6-Dinitro-2-Methyl Phenol	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
N-Nitrosodiphenylamine(1)	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected May 4-9, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)

C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-22

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
NVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE THREE

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Hexachlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Pentachlorophenol	50 U	50 U	50 U	R	NS	50 U	NS	50 U
Phenanthrene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Anthracene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Di-n-butyl phthalate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Fluoranthene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Pyrene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Butylbenzyl phthalate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
3,3-Dichlorobenzidine	20 U	20 U	20 U	20 U	NS	20 U	NS	20 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Chrysene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
›is(2-Ethylhexyl)phthalate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Di-n-octyl phthalate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
benzo(b)fluoranthene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Benzo(g,h.i)Perylene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
2,3,46-Tetrachlorophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
PyrAdine, 2-Methyl(2-Picolin)	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
Methanesulfonic Acid Ethyl	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
N-Nitrosopiperidine	20 U	20 U	20 U	20 U	NS	20 U	NS	20 U
2,6-Dichlorophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected May 4-9, 1992.
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NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)
C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-22

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
NVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE FOUR

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Methanesulfonic Acid, Methyl	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Acetophenone	50 U	50 U	50 U	10 U	NS	10 U	NS	10 U
A,A-Dimethylphenethylamine	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
Pentachlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
4-Aminobiphenyl	50 U	50 U	50 U	10 U	NS	10 U	NS	10 U
p-Dimethylamino-azobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
7,12-Dimethylbenzo(a)anthrace	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Diphenylamine	20 U	20 U	10 U	10 U	NS	10 U	NS	10 U
Phenacetin	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
3-Methylcholanthrene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Pronamide	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
1,4-Benzenediamine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Isosafrole	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
2-Napthaleneamine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
5-Nitro-o-toluidine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
4-Nitroquionoline 1-oxide	R	R	R	R	NS	R	NS	R
Methapyrilene	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
2-Acetylaminofluorene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
N-Nitrosomethylethylamine	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
N-Nitrosodiethylamine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
N-Nitrosomorpholine	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
o-Toluidine	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds. Samples collected May 4-9, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)

C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-22

SEMIVOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE FIVE

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
0,0,0-Triethylphosphorthioat	50 U	50 U	50 U	50 U	NS	50 U	NS	50 U
Pentachloronitrobenzene	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Safrole	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,4-Naphthoquinone	50 UJ	50 UJ	50 UJ	50 UJ	NS	50 UJ	NS	50 UJ
1,3,5-Trinitrobenzene	50 UJ	50 UJ	50 UJ	50 UJ	NS	50 UJ	NS	50 UJ
Hexachloropropene	R	R	R	R	NS	R	NS	R
1,3-Dinitrobenzene	20 UJ	20 UJ	20 UJ	20 UJ	NS	20 UJ	NS	20 UJ
3,3-Dimethylbenzidine	NS	NS	NS	NS	NS	NS	NS	NS
Hexachlorophene	1000 UJ	1000 UJ	1000 UJ	1000 UJ	NS	1000 UJ	NS	1000 UJ
Dimethoate	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
Diallate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Pyridine	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
Aramite	50 UJ	50 UJ	50 UJ	50 UJ	NS	50 UJ	NS	50 UJ
2-Secbutyl-4,6-Dinitrophenol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
M-Cresol	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U

Data Qualifier Legend

(a) - RCRA Appendix IX semivolatile organic compounds.
Samples collected May 4-9, 1992.

J - The associated numerical value is an estimated quantity.

NS - Not sampled.

R - Data Rejected. (Note: Analyte may or may not be present.)

U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.

UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W)

C - Duplicate surface water sample (i.e., SW06C)

TABLE 4-23

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Chloromethane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Bromomethane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Vinyl Chloride	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Chloroethane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Methylene Chloride	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Acetone	28 J	32 J	37 J	10 UJ	NS	21 J	NS	18 J
Carbon Disulfide	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,1-Dichloroethene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,2-Dichloroethene(total)	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Chloroform	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,2-Dichloroethane	5 UJ	5 UJ	5 UJ	5 UJ	NS	5 UJ	NS	5 UJ
2-Butanone	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Carbon Tetrachloride	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Vinyl Acetate	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
Bromodichloromethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,2-Dichloropropane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
cid-1,3-Dichloropropene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Trichloroethene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Dibromochloromethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Benzene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Bromoform	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
4-Methyl-2-pentanone	6 J	6 J	7 J	7 J	NS	7 J	NS	7 J
2-Hexanone	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
Tetrachloroethene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Toluene	5 U	5 U	5 U	5 UJ	NS	5 U	NS	5 U
1,1,2,2-Tetrachloroethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Ethylbenzene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Styrene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Xylene(total)	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U

Data Qualifier Legend

(a) - RCRA Appendix 9 volatile organic compounds.
Samples collected May 4-9, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-23

VOLATILE ORGANIC COMPOUNDS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

PAGE TWO

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Arolein	100 U	100 U	100 U	100 U	NS	100 U	NS	100 U
Acrylonitrile	100 U	100 U	100 U	100 U	NS	100 U	NS	100 U
2-Napthaleneamine	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Dichlorodifluoromethane	5 UJ	5 UJ	5 UJ	5 UJ	NS	5 UJ	NS	5 UJ
Iodomethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Dibromomethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Ethyl Methacrylate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,2,3-Trichloropropane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
14-Dichloro-2-butene	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
AllyL Chloride	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Propionitrile	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Methacrylonitrile	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
Methylmethacrylate	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
1,2-Dibromoethane	5 U	5 U	5 U	5 U	NS	5 U	NS	5 U
1,1,12-Tetrachloroethane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U
Pentachloroethane	10 UJ	10 UJ	10 UJ	10 UJ	NS	10 UJ	NS	10 UJ
12-Dibromo-3-chloropropane	10 U	10 U	10 U	10 U	NS	10 U	NS	10 U

Data Qualifier Legend

(a) - RCRA Appendix 9 volatile organic compounds.
Samples collected May 4-9, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-24

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs), AND RADIOACTIVITY IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
PESTICIDES								
a-BHC	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
B-BHC	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
d-BHC	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
v-BHC(Lindane)	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
Heptachlor	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
Aldrin	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
Heptachlor Epoxide	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
Endosulfan 1	0.050 U	NS	0.050 U	0.050 U	NS	0.050 U	NS	0.050 U
Dieldrin	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
4,4'-DDE	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
Endrin	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
Endosulfan II	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
4,4'-DDD	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
Endosulfan Sulfate	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
4,4' - DDT	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
Methoxychlor	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Endrin Ketone	0.10 U	NS	0.10 U	0.10 U	NS	0.10 U	NS	0.10 U
a-Chlordane	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
b-Chlordane	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Toxaphene	1.00 U	NS	1.00 U	1.00 U	NS	1.00 U	NS	1.00 U

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected May 4-9, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either thesample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-24

PESTICIDES, POLYCHLORINATED BIPHENYLS (PCBs), AND RADIOACTIVITY IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Chlorpyrifos (Dursban)	6.1	NS	0.5 U	0.5 U	NS	0.5 U	NS	0.5 U
Demeton	0.5 U	NS	0.5 U	0.5 U	NS	0.5 U	NS	0.5 U
Guthion	0.5 U	NS	0.5 U	0.5 U	NS	0.5 U	NS	0.5 U
Malathion	0.5 U	NS	0.5 U	0.5 U	NS	0.5 U	NS	0.5 U
Mirex	0.1 U	NS	0.1 U	0.1 U	NS	0.1 U	NS	0.1 U
Parathion	0.5 U	NS	0.5 U	0.5 U	NS	0.5 U	NS	0.5 U
2,4,5-TP Silvex	< 0.05	NS	< 0.05	< 0.05	NS	< 0.05	NS	< 0.05
POLYCHLORINATED BIPHENYLS(PCBs) (a)								
Aroclor-1016	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Aroclor-1221	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Aroclor-1232	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Aroclor-1242	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Aroclor-1248	0.50 U	NS	0.50 U	0.50 U	NS	0.50 U	NS	0.50 U
Aroclor-1254	1.00 U	NS	1.00 U	1.00 U	NS	1.00 U	NS	1.00 U
Aroclor-1260	1.00 U	NS	1.00 U	1.00 U	NS	1.00 U	NS	1.00 U
RADIOACTIVITY								
Gross Alpha Screen	5.3 +/ 2.6	NS	< 3	2.7 +/- 1.7	NS	NS	NS	8.3 +/- 2.6
Gross Beta Screen	< 4	NS	< 3	4.9 +/- 2.6	NS	NS	NS	< 4

Data Qualifier Legend

(a) - EPA SW8080 compounds. Samples collected May 4-9, 1992.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either thesample quantitation limit or the sample detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW01W).
C - Duplicate surface water sample (i.e., SW06C).

TABLE 4-25

CONTAMINANT INDICATOR LEVELS IN SURFACE WATER (a)
INVESTIGATION OF CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sample Location	Kuhlman Creek		Crutcho Creek					Elm Creek
Sample Number	SW01W	SW05W	SW06W	SW06C	SW11W	SW15W	SW20W	SW22AW
Units	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Alkalinity, Bicarbonate (as CaCO3)	250	280	390	350	300	390	480	210
BOD5	<0.1	NS	<0.1	<0.1	<0.1	<0.1	<0.1	1.8
COD	16	24	16	13	24	33	21	7
Carbon, Organic-Nonpurgeable	4	5	5	4	6	6	5	2
Chloride(Cl)	200	64	190	200	69	38	270	8
Fluoride	0.4	0.6	0.3	0.5	0.4	0.6	1.2	0.4
Hardness, Total	220	870	370	380	280	370	540	200
Methane Blue Active Substances	<0.03	NS	<0.03	<0.03	<0.03	NS	<0.03	0.03
Nitrate (as N)	1.1	4.2	0.6	0.6	0.6	< 0.1	0.9	0.1
Solids, Dissolved (180 C)	420	430	750	710	450	440	1000	240
Solids, Suspended (103 C)	< 10	17	< 10	< 10	14	30	43	18
Turbidity	15	NS	13	8	18	22	14	27

Data Qualifier Legend

(a) - Samples collected May 4-9, 1992.
(b) - Results for Specific Conductance are reported in microhms/cm and for Turbidity in NTU.
J - The associated numerical value is an estimated quantity.
NS - Not sampled.
R - Data Rejected. (Note: Analyte may or may not be present.)
U - The compound was not detected above the level of the associated value, which is either the sample quantitation limit or detection limit.
UJ - The compound was not detected above the associated value, which is an estimate and may be inaccurate.

Sample Number Legend

W - Surface water sample (i.e., SW06W).
C - Duplicate surface water sample (i.e., SW06C)

amount of suspended solids, 43 mg/l. In the other six samples, suspended solids fell below 30 mg/l. Turbidity ranged from 13 to 27 Nephelometric Turbidity Units (NTUs).

4.4 BASELINE AND CONFIRMATION DATA COMPARISON

During baseline activities, sediment and surface water samples were collected from 27 locations in July and October 1991. In February 1992, sediment and surface water samples were collected from 8 of the 27 baseline sample locations. The resampled locations areas follows:

- Kuhlman Creek — Sample locations 1, 3, and 5
- Crutcho Creek — Sample locations 6, 11, 15, and 20
- Tributaries of Elm Creek — Sample location 24

The baseline sample location SW22 could not be resampled due to low stream flow conditions in the tributaries of Elm Creek. Instead, sediment and surface water samples were collected from an upstream Location SW22A in February 1992.

During the May 1992 confirmation activities, surface water samples were collected for a third time from 6 sampling locations which included 1 and 5 on Kuhlman Creek and locations 6, 11, 15, and 20 on Crutcho Creek. Location SW22A on Elm Creek was resampled a second time.

4.4.1 Sediment Samples

In the July 1991 sediment samples, 17 inorganics were present in concentrations above laboratory detection limits. In February 1992, only 9 of the 17 inorganics were detected. Inorganics detected above laboratory detection limits at the same sample location in July 1991 and February 1992 include arsenic, barium, chromium, copper, lead, vanadium, and zinc. Mercury was detected in sediments during July 1991 and February 1992 sampling efforts, but at different sampling locations. In general, the concentrations of these inorganics were higher in February 1992 than in July 1991.

The majority of sediment samples from July 1991 and February 1992 did not contain detectable levels of pesticides or PCBs, except for the sediment sample SD01 from Kuhlman Creek. This sample contained the PCB, Aroclor-1260, at levels of 220 ug/kg in July 1991 and at ranges 120J to 160J ug/kg in February 1992.

The July 1991 sediment sample SD01 from Kuhlman Creek contained detected levels of nine SVOCs. These SVOCs were also detected in the February 1992 sediment samples SD01 and SD05 from Kuhlman Creek.

4.4.2 Surface Water Samples

In July and October 1991, baseline surface water samples were collected from 27 locations. The most commonly occurring inorganics detected in each sample included arsenic, barium, calcium, magnesium, sodium, lead, and zinc. In February 1992, confirmation samples were collected from 9 of the 27 original baseline locations. Eight of the nine locations had been sampled during baseline activities and include Locations 1, 3, 5, 6, 15, 20, and 24. Surface water samples from these locations also contained arsenic, barium, and zinc. Lead was only found in samples SW05 and SWB1. Selenium was detected in five February 1992 samples, but only once in the baseline sample SW14. The February 1992 samples were not tested for calcium, magnesium, or sodium. In May 1992, confirmation samples were collected for a third time from Locations 1, 5, 6, 15, and 20. A second confirmation sample was collected from Location 22A. As in February, these surface water samples contained detectable concentrations of arsenic, barium, and zinc. Vanadium was detected once in the May 1992 sample from Location 22A, but had been nondetectable in previous baseline or confirmation samples.

No pesticides or PCBs were detected in the surface water samples for either July 1991 or February 1992. One sample collected in May 1992 from Location 1 on Kuhlman Creek contained a low concentration, 6.1 ug/l, of the pesticide chlorpyrifos (i.e., Dursban). As previously stated, this surface water detection was the result of an isolated incident upstream, which involved a base construction subcontractor using the pesticide at a base construction site.

No SVOCs were present above detection limits in the July 1991 surface water samples. Only two SVOCs were detected in one February 1992 water sample, SW01. No SVOCs were found above laboratory detection limits in the May 1992 samples.

No VOCs were present in the July 1991 water samples. Xylenes (4J ug/l) were the only VOC detected in the February 1992 water samples. Two VOCs, acetone and 4-Methyl-2-pentanone, were found at low levels in each May 1992 surface water sample.

4.5 CHARACTERIZATION OF BACKGROUND CONDITIONS

In February 1992, sediment and surface water samples were collected from two sample locations in an effort to establish background conditions in Crutcho Creek, upstream of the base. These sample

Locations, B-1 and B-2, are shown in Figure 3-1 and are located approximately 2 miles south of Tinker AFB. These background locations were not resampled during May 1992 activities.

Sediment and surface water samples from B-1 and B-2 were analyzed for CIs, metals, pesticides/PCBs, SVOCs, cyanide, and radioactivity. In addition, surface water samples were also analyzed for MBAS and VOCs. The analytical results are presented in Tables 4-12 through 4-20. Background surface water conditions could not be established for Kuhlman or Elm Creeks, since they originate on the base.

No organic compounds were detected in the sediment or surface water samples. However, inorganics were detected above laboratory detection limits in sediment samples as shown below:

Inorganic	Value in B1[a]	Value in B2[a]
Arsenic	22.3 J	8.3J
Barium	10,500J	8690J
Cadmium	5.9J	5.4J
Chromium	122	59.5
Copper	61.9J	42.4J
Lead	73.5J	93J
Vanadium	211	178
Zinc	256	123

(a) Values reported in mg/kg.

Inorganics detected in the surface water samples at B1 included arsenic, barium, lead, selenium, and zinc. Of these only arsenic, barium, and selenium were reported in surface water samples at B2. All inorganics were reported at low concentrations below Federal MCLs. Concentration levels are given below:

Inorganics	Value in B1[a]	Value in B2[a]
Arsenic	1.1	1.2
Barium	534J	754J
Lead	1.8	
Selenium	1.2	1.2J
Zinc	14.2	

(a) Values reported in ug/l.

It has been previously documented that certain inorganics such as barium, chromium, zinc, nickel, and lead occur naturally in relatively high concentrations in the area (USACOE 1988). This finding would

explain the seemingly elevated levels of these inorganics in the background sediment samples and the barium content in the background surface water in the February 1992 data.

4.6 SUMMARY OF RESULTS

A summary of the results from this investigation is presented below:

- Sediment samples collected in July 1991 and in February 1992 were analyzed for Cls, VOCs, SVOCs, inorganics, pesticides, and PCBs. In the July 1991 sediment samples, 17 inorganics were found at levels above laboratory detection limits. In the February 1992 sediment samples, only nine inorganics were detected. Inorganics found during both sampling rounds include arsenic, barium, chromium, copper, lead, vanadium, and zinc. The concentration of these inorganics was higher in the February sampling than in the July sampling. These differences may be attributed to the seasonal rainfall variations. February is generally a dry part of the year in central Oklahoma while July is typically wetter.

- The majority of the sediment samples collected in July and February did not contain SVOCs, pesticides, or PCBs. The July and February sediment sample SD01 contained nine SVOCs. The February sample SD05 contained eight SVOCs. The PCB, Aroclor-1260 ,was detected in the July and February samples at Location 1 on Kuhlman Creek.

- Surface water samples in July 1991 and February and May 1992 were analyzed for inorganics, VOCs, SVOCs, Cls, pesticides, and PCBs. The majority of the samples contained inorganics. Nine inorganics were detected in the July and October samples, while only four were found in the February and May samples. Barium and arsenic were found at the same location during each sampling event. Zinc was detected in some samples from each sampling event. Lead was only detected in a few samples collected in July and February. Selenium was present in several samples in February and in one July sample. Vanadium was found in only one May 1992 sample. The July and February samples did not contain pesticides or PCBs. However, one sample in May contained a low concentration of chlorpyrifos, a pesticide. No SVOCs were found in the July samples. Only two February samples contained low levels of two SVOCs. No SVOCs were detected in the May samples. One VOC was detected in a February sample. Each sample in May contained two VOCs.

- Background surface water and sediment samples collected from Crutcho Creek did not contain VOCs, SVOCs, pesticides, or PCBs. However, inorganics were detected in all samples. Inorganics common to both surface water and sediment samples included arsenic,

barium, lead, and zinc. The concentrations of these inorganics were the highest for the February 1992 sediment analyses. The levels of barium and lead in the background surface water samples were also the highest in the February 1992 data.

4.7 QUALITY ASSURANCE /QUALITY CONTROL SUMMARY

This section contains a general summary of the results of quality control measures used to assess and control the analytical process. Data quality objectives and associated protocols for evaluating precision and accuracy of project data are identified in the Final Work Plan, Crutcho and Kuhlman Creeks and Tributaries of Elm Creek (HALLIBURTON NUS 1992). This document is further supported by the HALLIBURTON NUS Laboratory Quality Assurance Plan (HALLIBURTON NUS 1991) prepared in support of the Hazardous Waste Remedial Actions Program. Specific Data Quality Objectives, Corrective Actions as well as acceptance criteria used to evaluate the analytical data packages from the four individual sampling events can be found in Section 11.0 of the HALLIBURTON NUS Laboratory Services Group General Quality Assurance Plan (HALLIBURTON NUS 1989).

Data reports of the analyses performed for this project were reviewed in accordance with the Environmental Protection Agency's functional guidelines for organic and inorganic data validation (USEPA 1989 and USEPA 1988c) and Requirements for Quality Control of Analytical Data (HAZWRAP 1990). All laboratory analyses were performed in accordance with HAZWRAP Quality Assurance/Quality Control Level C, except for analyses of Target Analyte List (TAL) Metals and cyanide and miscellaneous Cls parameters which were performed under the requirements of HAZWRAP Quality Assurance/Quality Control Levels D and E, respectively.

In general, the data packages were evaluated for:

- Holding times
- Various duplicate analyses
- Equipment rinsate analyses
- Blank analyses (laboratory, field, and trip)
- Calibration
- Nonconforming data points
- PARCC parameters

All surface water and sediment samples were collected using direct sampling methods except for the February 1992 sediment samples. Rinsate and field quality control blanks were not collected if direct sampling methods were used. Data validation reports found in Appendix F (Volume 3 of 3) of this

report describe various irregularities observed with the reported analytical data. An abbreviated explanation of data anomalies are summarized below.

4.7.1 Sediment Samples - July 1991

The HALLIBURTON NUS Laboratory analyzed 29 soil samples (including three field duplicate pairs) for the various TAL metals, as well as six samples for cyanide. In addition, the laboratory analyzed seven soil samples for Appendix IX Organic (less herbicides) and miscellaneous CI parameters. There were no field quality control blanks included in this sample set. All holding times associated with this data set met HAZWRAP requirements. Of this sample set, one analyte data point was rejected due to an extremely low matrix spike recovery (less than 30 percent). Six other data points representing heptachlor epoxide were rejected because of continuing calibration percent differences greater than 50 percent on the quantitation column. All other data associated with this sample set were accepted, although several analytes were accepted with qualifiers.

4.7.1.1 Quality Control Blanks

Laboratory method blank analyses yielded concentrations of beryllium, cadmium, cobalt, chromium, iron, lead, nickel, and zinc. Positive sample results less than the established action levels are qualified as undetected. No data validation actions were taken because all sample concentrations for these analytes were above the established action levels.

Negative blank contamination was evident for antimony, arsenic, barium, magnesium, manganese, and vanadium. Positive results and nondetects for these analytes may not be accurate and were qualified as estimated "J" and "UJ" respectively.

4.7.1.2 Precision

The Relative Percent Difference (RPD) for iron exceeded the 50 percent quality control criterion in one of the field duplicate pairs. Positive iron results were qualified as estimated "J" due to this field duplicate imprecision. In addition, the RPD for calcium, magnesium, and manganese exceeded the 35 percent quality control limit for laboratory duplicates. Positive calcium and magnesium results were qualified as estimated "J" due to poor laboratory duplicate precision.

4.7.1.3 Accuracy

The matrix spike percent recovery for barium and silver were reported as less than 30 percent. Positive results for these analytes were qualified as estimated, "J". The nondetect for silver was considered unreliable and was rejected, "R".

Post digestion spike (PDS) percent recoveries for selenium and thallium in several samples were below the 85 percent lower quality control limits. The positive selenium result in sample TCC-SD10-E-0000 was qualified as estimated "J". The nondetects for thallium and selenium in affected samples have been qualified as estimated "UJ".

4.7.1.4 Calibration

The Contract Required Detection Limit (CRDL) standard analysis percent recoveries for several analytes were below 80 percent. No actions were necessary for beryllium, cadmium, magnesium, manganese, and zinc since all positive cadmium results less than three times the CRDL are qualified due to blank contamination and all positive results for manganese, magnesium, and zinc are greater than three times the CRDL. Positive results less than three times the CRDL and nondetects for the other analytes are qualified as estimated "J" and "UJ", respectively. The CRDL standard analysis percent recovery for nickel and silver exceeded the 120 percent upper quality control limit. Qualifications were not made because positive results less than three times the CRDL for these analytes are qualified on the basis of blank contamination.

Nondetects for endosulfan sulfate, δ-BHC, endrin and methoxychlor for several samples were qualified as estimated "UJ" because of continuing calibration percent differences being less than 15 percent on the quantitation column. The 4-aminobiphenyl and pesticide fraction nondetects were qualified as estimated "UJ" due to continuing calibration percent differences being greater than 50 percent.

4.7.2 Surface Water Samples - July 1991

The HALLIBURTON NUS Laboratory analyzed 24 water samples (including three field duplicate pairs) for various TAL metals (except aluminum, iron, manganese, and potassium), as well as four samples for cyanide. In addition, the laboratory analyzed seven water samples for Appendix IX Organic (less herbicides) and 23 samples for miscellaneous parameters. Two trip blanks were also analyzed for Appendix IX Organic Compounds. All holding times associated with this data set met HAZWRAP requirements. One analyte data point (silver) was rejected due to an extremely low matrix spike

recovery (less than 30 percent). All other data associated with this sample set were accepted, although several analytes were accepted with qualifiers.

4.7.2.1 Quality Control Blanks

Laboratory method blank analyses yielded evidence of beryllium, cadmium, chromium, cobalt, nickel, silver, vanadium, and zinc. Positive sample results less than the established action levels (Appendix F) are qualified as undetected "U". Adjustments for dilutions were made prior to application of the action levels. No data qualifications were required for cadmium or silver as no positive results were reported for these analytes.

Negative blank contamination was evident for antimony, arsenic, barium, calcium, chromium, vanadium, and zinc. Positive results for antimony, arsenic, barium, calcium, chromium, and zinc as well as nondetects for antimony, arsenic, calcium, chromium, and vanadium are qualified as estimated "J" and "UJ", respectively. No positive results were reported for vanadium.

Acetone was detected in a laboratory blank associated with the Appendix IX organics analysis. In addition, 4-methyl-2- pentone was detected in a trip blank. No qualifications were necessary since no positive results for these compounds were reported for any environmental samples.

4.7.2.2 Precision

The RPD for lead exceeded the 20 percent quality control limit for water analyses. Positive results for this analyte are qualified as estimated, "J". No nondetects were reported for this analyte.

4.7.2.3 Accuracy

The MS percent recovery for silver was between the 30 percent and 75 percent quality control limit. Only nondetects were reported for this analyte, and these results are qualified as estimated, "UJ". Matrix spike recoveries for endrin exceeded the upper quality control limit. No qualifications were made since there were no positive results reported for endrin in the unspiked sample.

Several samples had PDS percent recoveries for antimony, arsenic, and selenium below the 85 percent lower quality control limit. Positive arsenic results and nondetects for antimony in affected samples are qualified as estimated "J" and "UJ", respectively. Selenium nondetects in five samples are qualified as estimated, "UJ"; no actions were taken for the positive results in the other samples since these results are qualified because of blank contamination. The PDS percent recovery for lead in one

sample was in excess of 115. Qualification was not necessary since the affected sample result is a nondetect.

4.7.2.4 Calibration

The CRDL standard analysis percent recoveries for beryllium, chromium, and manganese were below the 80 percent lower quality control limit, while antimony, cadmium, silver, vanadium, and zinc exceeded the 120 percent upper quality control limit. No data qualifications were required since all positive beryllium, cadmium, vanadium, and zinc results less than three times CRDL are qualified due to blank contamination and all positive results for manganese are greater than three times CRDL. No positive results were reported for antimony. Nondetects reported for chromium and silver were qualified as "UJ".

The laboratory control sample percent recovery for silver exceeded the 120 percent quality control limit. However, no qualifications were made because no positive results were reported for this analyte. The initial calibration percent relative standard deviation (RSD) for several compounds exceeded the 20.5 percent quality control criterion, but were less than the 50 percent limit. No data qualifications were made since no positive results were reported for the affected compounds and nondetects are not impacted. The percent RSD for acetone exceeded the 50 percent quality control limit, subsequently, nondetects for acetone in all samples from this data set were qualified as estimated, "UJ".

The continuing calibration percent difference (percent differences) for several compounds exceeded the 50 percent quality control criterion. Nondetects for these compounds in the affected samples are qualified as estimated "UJ". Pripionitrile and several other compounds had continuing calibration percent differences that exceeded 25 percent, but were less than 50 percent; no qualifications were made since no positive results were reported for the affected compounds in associated samples.

The continuing calibration percent differences for several compounds exceeded 20 percent on the confirmation column. However, no qualifications were necessary since all quality control criteria were met for the quantitation column and the confirmation of nondetects is not impacted by this noncompliance.

4.7.3 Surface Water Samples - October 1991

The HALLIBURTON NUS Laboratory analyzed six water samples (including two field duplicate pairs) for TAL metals except aluminum, iron, manganese, and potassium. In addition, the laboratory

analyzed six water samples for miscellaneous Cl parameters. There were no field quality control blanks included in this sample set. All holding times associated with this data set met HAZWRAP requirements. All data associated with this sample set were accepted, although several analytes were accepted with qualifiers.

4.7.3.1 Quality Control Blanks

Laboratory method blank analysis yielded evidence of beryllium and cobalt. Positive sample results less than the established action levels (Appendix F) are qualified as undetected "U".

Negative blank contamination was evident for barium, calcium, vanadium, and zinc. Consequently, positive results and nondetects for these analytes are qualified as estimated "J" and "UJ" respectively. No positive results were reported for vanadium and no nondetects were reported for barium and calcium.

4.7.3.2 Precision

The RPD for calcium, lead, and suspended solids in laboratory duplicate samples exceeded the 20 percent quality control criterion for water analyses. Positive results and nondetects for these analytes have been qualified as estimated "J" and "UJ" respectively due to laboratory duplicate imprecision.

The RPDs for COD and TOX exceeded 30 percent for the field duplicate pair consisting of samples TCC-SW13-W001 and TCC-SW13-C001. Positive results and nondetects for these parameters in this sample pair are qualified as estimated "J" and "UJ", respectively; No nondetects were reported for COD.

4.7.3.3 Accuracy

Matrix spike recovery for the total organic halogens (EOX orTOX) analysis was less than 75 percent and above 30 percent. Positive results and nondetects for this parameter are qualified as estimated "J" and "UJ", respectively.

PDS percent recoveries for arsenic in four samples and antimony in one sample were below the 85 percent lower quality control limit. Positive arsenic results in affected samples are qualified as estimated "J". The antimony nondetect in sample TCC-SW25- W0001 was qualified as estimated "UJ".

4.7.3.4 Calibration

CRDL standard analysis percent recoveries (percent recoveries) for cadmium, chromium, and vanadium were below the 80 percent lower quality control limit, while copper and silver exceeded the 120 percent upper quality control limit. Only nondetects were reported for these analytes, and these results were qualified as estimated"UJ". Positive copper results less than three times the CRDL were qualified as estimated"J". No other actions were taken because all positive results for silver were greater than the CRDL.

4.7.4 Sediment Samples - February 1992

The HALLIBURTON NUS Laboratory analyzed nine soil samples (including one field duplicate pair), one field blank and one rinsate blank for all TAL metals except aluminum, calcium, iron, magnesium, manganese, potassium, and sodium. Nine samples from this sample set were also analyzed for cyanide. In addition, the laboratory analyzed nine soil samples (including one field duplicate pair), one field blank, and one rinsate blank for Target Compound List (TCL) semivolatiles, and pesticide/PCB organic compounds. Thirteen soil samples (including two field duplicate pairs), one field blank, and one rinsate blank were also analyzed for miscellaneous CI parameters such as alkalinity, chemical oxygen demand (COD), chloride, dissolved solids, nitrate, suspended solids, nonpurgeable organic carbon, total organic carbon (TOC), direct fluoride, total hardness, chlorinated herbicides, gross alpha and beta, pH, TOX, percent moisture, grain size, and percent solids. All holding times associated with this data set met HAZWRAP requirements.

Several semivolatile fractions were rejected. The results for 3,3'-dimethylbenzidine were rejected because the method being used was unable to detect this analyte. Nondetects for 4-nitroquinoline-1-oxide and hexachloropropene were rejected because the initial and continuing calibration average relative response factor (RRF average) was less than 0.05. There were no positive results for these compounds and the associated nondetects were considered unreliable. All other data associated with this sample set were accepted, although several analytes were accepted with qualifiers.

4.7.4.1 Quality Control Blanks

Laboratory method blank analysis yielded evidence of beryllium, cobalt, nickel, and zinc. Positive sample results less than the established action levels (Appendix F) except zinc are qualified as undetected "U". The positive results for zinc exceeded the action level, so no qualifications were needed.

Negative blank contamination was evident for barium in the laboratory method blanks. Consequently, positive results for this analyte are qualified as estimated "J", no nondetects were reported.

Positive concentrations were reported for alkalinity, chloride, dissolved solids and fluoride in the field blanks. No data validation actions were necessary since positive results for these parameters in the affected samples exceeded the maximum contaminant concentrations.

4.7.4.2 Precision

RPD for lead and mercury exceeded the 50 percent quality control criterion for soil analyses. Positive results and nondetects for these analytes are qualified as estimated "J" and "UJ", respectively.

RPD for nitrate, TOC, alkalinity, and TOX were high in field duplicate pair samples TKC-SD01-F-0002 and TKC-SD01-E- 0002. Sample data for these parameters in these samples are qualified as estimated "J" and "UJ", respectively. There were no nondetects reported for nitrate, TOC, and TOX. Nonpurgeable organic carbon, COD, and fluoride relative percent differences were also high in field duplicate pair samples TKC-SW01-C-0002 and TKC-SW01-W-0002. Positive results for these parameters in these samples are qualified as estimated "J".

4.7.4.3 Accuracy

Matrix spike recovery for antimony, arsenic, barium, selenium, chloride, EOX and TOC exceeded quality control limits. Positive results and nondetects for these analytes were qualified as estimated "J" and "UJ", respectively. There were no nondetects reported for arsenic, chloride or TOC analyses.

Post Digestion Spike (PDS) percent recoveries for selenium in most samples from this sample set exceeded the 85 percent lower quality control limit. Nondetects in affected samples were qualified as estimated "UJ". There were no positive results reported.

4.7.4.4 Calibration

The CRDL standard analysis percent recovery for chromium, cadmium, copper and nickel exceeded the quality control limits. Positive results for cadmium and copper were qualified as estimated "J". Positive results for chromium were less than 3 times the CRDL so no action was taken. No further action was taken for the analyte nickel due to blank contamination previously reported.

Nondetects for the analytes isosafrole, 1,4-naphthoquinone, M-dinitrobenzene, and pyridine were qualified as estimated "UJ" due to initial calibration percent RSD being less than 50 percent.

The analytes A,A'-dimethylphenethylamine, 4-nitrophenol, M-cresol, methylapyriline, 1,4-naphthoquinone, aramite, N- nitrosomorpholine, diallite, and syn-trinitrobenzene had continuing calibration percent differences greater than 50 percent and were qualified as estimated "UJ".

4.7.5 Surface Water Samples - February 1992

The HALLIBURTON NUS Laboratory analyzed 11 water samples (including two field duplicate pair) for all TAL metals except aluminum, calcium, iron, magnesium, manganese, potassium, and sodium. Seven samples from this sample set were also analyzed for cyanide. In addition, the laboratory analyzed nine water samples (including one field duplicate pair) and four trip blanks for modified TCL volatile organic compounds. Nine of these samples were also analyzed for semivolatiles and pesticide/PCB organic compounds. All holding times associated with this data set met HAZWRAP requirements.

Resource Analysts Inc., Laboratories analyzed eight water samples (including one field duplicate pair) for organophosphorous and organochlorine pesticide compounds. No associated field quality control blanks were analyzed under this analytical sample set.

Alpha Analytical Laboratories analyzed 13 water samples (including two field duplicate pairs) for BOD, Methylene Blue Activated Substances (MBAS), and turbidity. There were no associated field blanks analyzed with this sample set. The 48-hour holding time for BOD was exceeded for sample TCC-SW17A-W-0002. The nondetect result in this sample was qualified as estimated "UJ".

All other data associated with this sample set was accepted with the following qualifications.

4.7.5.1 Quality Control Blanks

Laboratory method blank analysis yielded concentrations of beryllium and cadmium. Positive results for these analytes were less than the action levels and were qualified as undetected "U".

Negative blank contamination levels were evident for barium and vanadium. Consequently, positive results and nondetects for these analytes are qualified as estimated "J" and "UJ", respectively. No positive results were reported for vanadium and no nondetects were reported for barium.

Low levels of 2-hexanone and acrylonitrile were detected in trip and/or laboratory blank analyses. Action levels five times the maximum amount of the other contaminants detected were used to evaluate the data. No qualifications were required for these two compounds because no positive results were reported for these compounds in any samples.

4.7.5.2 Precision

The RPD for di-n-octylphthalate exceeded quality control limits for the water field duplicate pair (TKC-SW01-C0002 and TKC-SW01-W0002). The positive result and nondetects for this compound in the field duplicate pair samples are qualified as estimated "J" or "UJ".

4.7.5.3 Accuracy

Graphite furnace PDS recovery for selenium and thallium in one sample were below the 85 percent lower quality control criterion. The positive selenium result in sample TCC-SW02-W-0002 and the nondetects for Thallium in sample TCC-SW20-W-0002 were qualified as estimated "J" and "UJ", respectively.

Three samples had high (greater than 115 percent) PDS recoveries for lead. Qualifications were not needed as reported results in the affected samples were nondetects.

4.7.5.4 Calibration

The CRDL Standard analysis percent recovery for vanadium was below the 80 percent lower quality control limit. Only nondetects were reported for this analyte and were reported as estimated "UJ". Cadmium CRDL Standard analysis percent recovery exceeded the 120 percent upper quality control limit. No qualifications were required because all positive results less than three times CRDL for this analyte were qualified due to blank contamination.

The positive result for xylene (total) in sample TKC-SW05- W0002 was qualified as estimated "J" because of reported concentrations below the CRQL.

An initial calibration percent RSD for A,A-dimethylphenethlamine exceeded 50 percent. Nondetects for this compound in affected samples have been qualified as estimated "UJ". There were no positive results reported.

The nondetects results for trans-1,4-dichloro-2- butene in two samples were rejected due to continuing calibration RRF being less than 0.05.

Volatile fraction nondetects for acetone, iodomethane, allyl chloride, methylene bromide, 4-methyl-2-pentanone, and dichloro-difluoromethane as well as some semivolatile fraction nondetects for 4-nitrophenol and A,A-dimethylphenethylamine were qualified as estimated "UJ" due to continuing calibration percent differences exceeding 50.

Continuing calibration percent differences for several compounds (volatile and semivolatile fractions) exceeded the 25 percent quality control criterion, but no qualifications were made because there were no positive results reported for these compounds in affected samples.

4.7.6 Surface Water Samples - May 1992

The HALLIBURTON NUS Laboratory analyzed five water samples (including one field duplicate pair), for all TAL metals except aluminum, calcium, iron, magnesium, manganese, potassium, and sodium. There were no field quality control blanks analyzed as part of this sample set. The laboratory also analyzed six water samples (including one field duplicate pair), and one trip blank for modified TCL volatile organic compounds. Six of these samples were also analyzed for semivolatiles and pesticide/PCB organic compounds. In addition, the HALLIBURTON NUS Laboratory analyzed eight samples for miscellaneous CI parameters.

Resource Analysts Inc., Laboratories analyzed five water samples (including one field duplicate pair) for organophosphorous pesticide organic compounds. No associated field quality control blanks were analyzed under this analytical sample set.

Alpha Analytical Laboratories analyzed 10 water samples (including one field duplicate pair and Matrix Spike/Matrix Spike Duplicate samples) for BOD, MBAS, and turbidity. There were no associated field blanks analyzed with this sample set. Initial and/or continuing calibration relative response factors for 4-nitroquinoline 1-oxide, hexachloropropene, and trans-1,4-dichloro-2-butene in two samples fell below the 0.05 quality control limit. Nondetects for these compounds in the affected samples are considered unreliable and were qualified as rejected, "R".

The matrix spike duplicate percent recovery for pentachlorophenol was below 10 percent. The nondetect for this compound was considered unreliable and qualified as rejected "R" in sample TCC-SW06- C0003.

All other data associated with this sample set were accepted with the following qualifiers.

4.7.6.1 Quality Control Blanks

Barium, beryllium, cadmium, lead, silver, 2-butanone, and methylene chloride contamination was found in the laboratory blank analyses. No qualifications were required for barium since all positive results for this analyte exceeded the established action level. Positive results less than the action levels for beryllium, cadmium, lead and silver are qualified as undetected "U". A negative concentration was reported for chromium in a laboratory method blank; the absolute value of the concentration was at the Instrument detection level. Only nondetects for this analyte were reported and these results are qualified as estimated "UJ".

4.7.6.2 Precision

The RPD for lead and cadmium exceeded the quality control limits for laboratory duplicates. Cadmium nondetects are qualified as estimated "UJ"; no nondetects were reported for lead. Positive results for both analytes are qualified on the basis of blank contamination, thus no further actions were required.

The RPD for acetone exceeded the 30 percent quality control criteria for field duplicate pair TCC-SW06-C0003 and TCC- SW06-W0003. The positive result and nondetect for this compound in the field duplicate pair samples have been qualified as "J" and "UJ", respectively.

4.7.6.3 Accuracy

The matrix spike/matrix spike duplicate percent recoveries for mercury, malathion/fenthion, and parathion exceeded the upper quality control limits. No actions were taken as there were no positive results reported for these compounds in the unspiked sample. The matrix spike percent recovery for thallium and toluene were below the lower quality control limit. Nondetects were qualified as estimated "UJ". There were no positive results reported.

Post digestion spike (PDS) percent recoveries for lead in one sample and thallium in three other samples were below the 85 percent lower quality control limit. Thallium nondetects in the affected

samples are qualified as estimated "UJ". No further action was taken for the positive lead result in the affected sample because this result is qualified due to blank contamination.

4.7.6.4 Calibration

The CRDL standard analysis percent recoveries for beryllium, cadmium, silver, and zinc exceeded the 120 percent upper quality control limit. Positive zinc results less than three times CRDL are qualified as estimated "J". No further actions were taken for the remaining analytes because all positive results for these metals less than three times CRDL are qualified based on blank contamination.

CRDL standard analysis percent recoveries for chromium and selenium were below the 80 percent lower quality control limit. Only nondetects were reported for these analytes and these results are qualified as estimated "UJ".

The initial calibration percent (RSD) for pentachloroethane, 2- picoline, pronamide, isosafrole, 1,4-naphthoquinone, hexachloropropene, 1,3-dinitrobenzene, and pyridine exceeded 50 percent. Nondetects for all of these compounds except hexachloropropene were qualified as estimated "UJ". No action was taken for hexachloropropene as associated nondetects have been qualified based on noncompliant response factors. No positive results for these analytes were reported.

The continuing calibration percent differences for acetone, 1,2- dichloroethane, vinyl acetate, 2-hexanone, dichlorodifluoromethane, and pentachloroethane exceeded 50 percent. Positive results and nondetects for these compounds in affected samples have been qualified as estimated "J" and "UJ", respectively. The continuing calibration percent differences for several other compounds exceeded the 25 percent quality control criterion. No qualifications were required because no positive results were reported for these compounds in affected samples.

4.7.7 Representativeness

Representativeness is a measurement of the degree to which data accurately and precisely represent the sampling point parameters or an environmental condition. Several elements throughout the sampling and sample handling process must be controlled to maximize the representativeness of analytical data. These include the sampling plan, sample collection, sample preservation, and the lapse of time between sampling and the initiation of analysis (the holding time). Sample collection, sample preservation, and holding times are discussed in Section 3 of this document.

Laboratory samples were stirred, shaken, crushed, and/or blended as appropriate for the sample matrix and the parameters of interest in order to maximize the representativeness of the sample aliquots taken for analysis.

The sampling plan utilized during this investigation was designed to provide both temporal and spatial information regarding the nature and extent of contaminants. This has been accomplished by sampling three times during the year and by locating sample points at intermediate points along the three creeks as well as at major contamination sources. The sampling described in this report has been successful in that respect.

4.7.8 Comparability

Comparability is the degree of confidence with which one set of data can be compared to a related set of data. The comparability of HALLIBURTON NUS data is enhanced by the use of EPA-approved methodology whenever available, participation in internal and external performance evaluation programs, and periodic analysis of reference materials. In addition, data are expressed using consistent reporting limits in units commonly used in reporting environmental data.

The surface water samples collected in July 1991, October 1991, February 1992, and May 1992 were handled, shipped, and analyzed using the same procedures and methods. The surface water and sediment samples were collected using slightly different methods. The July 1991 sediment samples were collected using the sample container to collect the sample whereas in February 1992, stainless steel spoons was used to collect the samples. The July and October 1991 surface water samples were collected using a clean dedicated sample container and then transferring the water into individual sample bottles for shipment to the lab whereas in February, all samples were collected in the individual sample bottles. The impact of these changes on comparability should be small.

4.7.9 Completeness

Completeness is a measure of the amount of valid data (i.e., data that was generated according to appropriate methodology, and meets HALLIBURTON NUS and project specific quality control requirements and holding times) obtained from a measurement system relative to the amount that was expected to be generated under correct normal conditions. HALLIBURTON NUS evaluates completeness through its data quality assessment procedures.

Data completeness was computed based on a total of 8624 analyses being performed during the four separate sampling events. Of these analyses, all but one met the required holding times and only 83 analyses were rejected for unacceptable results. Overall completeness of the data reviewed for this project was calculated to be approximately 99 percent.

4.7.10 Summary

The majority of data collected during four sampling events (July 1991, October 1991, February 1992, and May 1992) for this project met the established Quality Control requirements as specified in the Final Work Plan, Crutcho and Kuhlman Creeks and Tributaries of Elm Creek (HALLIBURTON NUS 1992),and the HALLIBURTON NUS Laboratory Quality Assurance Plan prepared for HAZWRAP. Therefore, the analytical data presented in this report is technically sound, legally defensible, and of sufficient quality to base decisions regarding disposition of the creeks. In addition, all DQOs stated in the work plan and QA project plan were achieved.

5.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport of the organic and inorganic compounds found in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek are discussed in this section. Chemical and physical properties of the detected chemicals that affect their migration are presented in Section 5.1. Section 5.2 discusses contaminant persistence, and Section 5.3 identifies potential contaminant migration routes.

5.1 PHYSICAL AND CHEMICAL PROPERTIES OF SITE CONTAMINANTS

Physical and chemical properties of site contaminants are presented and discussed in this section. These parameters are used to provide estimates of contaminant behavior in the environment. Table 5-1 presents environmental fate and transport parameters for inorganic chemicals. Table 5-2 presents the physical and chemical properties for the organic chemicals found in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek.

The environmental mobility of inorganic elements is a complex issue which cannot be dealt with as readily as the mobility of organic compounds. Site-specific information sufficient to characterize all of the factors affecting inorganic mobility can seldom be obtained short of research-oriented investigations. Some of the factors affecting the mobility and behavior of inorganic species in the environment are as follows:

- Valence state and ion size
- Speciation
- Solubility products and precipitation reactions
- Adsorption and cation exchange
- Soil reaction (pH)
- Oxidation-reduction potential (Eh)
- Inorganic complexation
- Organo-metallic complexation
- Common ion effects
- Competing reactions
- Soil/Water Distribution Coefficient (K_d)
- Bioconcentration Factor

TABLE 5-1
ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS
FOR SELECTED INORGANICS
CRUTCHO AND KUHLMAN CREEKS AND THE TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Element	Molecular Weight (g/mole)	Soil/Water Distribution Coefficient (K_d) Range[a] (ml/g)	Bioconcentration Factor[b] (ug/kg/ug/l)
Antimony	121.75	45[c]	1
Arsenic (III)	74.92	1.0-8.3	44
Barium	137.33	60[c]	1
Beryllium	9.01	650[c]	19
Chromium (III)	51.99	470-150,000	16
Cobalt	58.93	0.2-3,800	1
Copper	63.54	1.4-333	36
Lead	207.19	4.5-7,640	1
Manganese	54.94	0.2-10,000	1
Mercury	200.59	10[c]	1
Selenium	78.96	1.2-8.6	4.8
Vanadium	50.94	NR	1
Zinc	65.38	0.1-8,000	47

NR Not reported.
(a) Dragun 1988.
(b) USEPA 1991; Assume 1.0 for nonreported metals
(c) Oak Ridge National Laboratory 1984

TABLE 5-2

PHYSICAL AND CHEMICAL CHARACTERISTICS OF ORGANIC CHEMICALS
KUHLMAN AND CRUTCHO CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AFB
OKLAHOMA CITY, OKLAHOMA

CAS Number	Chemical	Molecular Weight[1][2]	Specific Gravity (20/4°C)[2]	Vapor Pressure @20°C (mm Hg)[1]	Water Solubility @20°C (mg/l)[1]	Octanol/Water Partition Coefficient[1]	Organic Carbon Partition Coefficient[1]	Henry's Law Constant (atm-m3/mo e)[1]	Bioconcentration Factor (mg/kg/mg/l)[6]
KETONES									
67-64-1	Acetone	58.08	0.791	270 (30°C)	(7)	NA	9.2	3.43×10^{-5}	3.0×10^{-1}
108-10-1	4-Methyl-2-Pentanone	100.2	0.802	6.0	17,000	15.4	113	4.16×10^{-5}	5.2×10^{0}
MONOCYCLIC AROMATICS									
1330-20-7	Xylenes	106.16	0.870	5.8[5]	187	1,195	248	4.33×10^{-3}	1.5×10^{2}
PHTHALATE ESTERS									
117-81-7	Bis(2-ethylhexyl)phthalate	391	0.99 (20/20°C)	2×10^{-7}	4.0×10^{-1} (25°C)	4.1×10^{9}	2.0×10^{9}	3×10^{-7}	1.3×10^{2}
84-74-2	Di-n-butylphthalate	278.3	1.05	1.0×10^{-5} (25°C)	1.3×10^{1} (25°C)	3.6×10^{5}	1.7×10^{5}	2.8×10^{-5}	8.9×10^{1}
117-84-0	Di-n-octylphthalate	391	0.99 (20/20°C)	1.4×10^{-4} (25°C)	3.0×10^{0} (25°C)	7.4×10^{9}	3.6×10^{9}	1.7×10^{-5}	9.4×10^{3}
POLYNUCLEAR AROMATIC HYDROCARBONS									
56-55-3	Benzo(a)anthracene	228.3	NA	2.2×10^{-8}	5.7×10^{-3}	4.1×10^{5}	2.0×10^{5}	1.0×10^{-6}	3.0×10^{1}
205-99-2	Benzo(b)fluoranthene	252.3	NA	5.0×10^{-7}	1.4×10^{-2} (25°C)	1.15×10^{6}	5.5×10^{6}	1.22×10^{-5}	3.0×10^{1}
191-24-2	Benzo(g,h,i)perylene	276	NA	1.03×10^{-10} (25°C)	2.6×10^{-4} (25°C)	3.2×10^{6}	1.6×10^{6}	1.44×10^{-7}	3.5×10^{5}[1]
50-32-8	Benzo(a)pyrene	252	NA	5.6×10^{-9} (25°C)	3.8×10^{-3} (25°C)	1.15×10^{6}	5.5×10^{6}	4.9×10^{-7}	3.0×10^{1}
218-01-9	Chrysene	228.3	1.27	6.3×10^{-9} (25°C)	1.8×10^{-3} (25°C)	4.1×10^{5}	2.0×10^{5}	1.05×10^{-6}	3.0×10^{1}
206-44-0	Fluoranthene	202.3	NA	5.0×10^{-6} (25°C)	2.6×10^{-1} (25°C)	7.9×10^{4}	3.8×10^{4}	6.5×10^{-6}	1.15×10^{3}
193-39-5	Indeno(1,2,3-cd)pyrene	276.3	NA	1.0×10^{-10}	5.3×10^{-4} (25°C)	3.2×10^{6}	1.6×10^{6}	6.95×10^{-8}	3.0×10^{1}
85-01-1	Phenanthrene	178.2	1.02	9.6×10^{-4} (25°C)	1.0×10^{0} (25°C)	2.8×10^{4}	1.4×10^{4}	2.26×10^{-4}	4.7×10^{3}[1]
129-00-0	Pyrene	202.3	1.27[8]	2.5×10^{-6} (25°C)	1.3×10^{-1} (25°C)	8.0×10^{4}	3.8×10^{4}	5.1×10^{-6}	3.0×10^{1}
POLYCHLORINATED BIPHENYLS									
11096-82-5	Aroclor - 1260	375.7	NA	4.1×10^{-5} (25°C)	2.7×10^{-3} (25°C)	1.4×10^{7}	6.7×10^{6}	7.4×10^{-1}	3.12×10^{4}
PESTICIDES									
72-54-8	4,4'-DDD	320	NA	1.02×10^{-6} (30°C)	5.5×10^{-2}[11]	1.6×10^{6}	7.7×10^{5}	2.2×10^{-3}	5.36×10^{4}
2921-88-2	Chlorpyrifos	350.59	NA	1.87×10^{-5}(25°C)	2(25°C)[8]	NA	2.98×10^{3}[9]	NA	4.7×10^{2}[10]

NA Not Available
(1) US EPA, December 1982.
(2) Verscheuren 1983.
(3) US EPA, October 1980(a).
(4) US EPA, IRIS on-line.
(5) Average values for otho, para- and meta-isomers.
(6) EPA 1991
(7) Compound is reportedly totally miscible in water
(8) Windholz 1983
(9) Lyman et al. 1990, eq. 4-5
(10) Lyman et al. 1990

Empirically determined literature values of parameters affecting the mobility of organic chemicals include:

- Specific gravity
- Vapor pressure
- Water solubility
- Octanol/water partition coefficients
- Organic carbon partition coefficients
- Henry's Law constants
- Bioconcentration factors

These parameters are presented when available. Calculated values, which were obtained using approximation methods, are given when literature values are not available. A discussion of the environmental significance of each of these parameters follows.

5.1.1 Specific Gravity

Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at the same temperature. Its primary use is to determine whether a contaminant will have a tendency to float or sink in water if it is present as a pure compound or at very high concentrations. Contaminants with a specific gravity less than 1.0 will tend to float, while those contaminants with specific gravities greater than 1.0 will tend to sink.

5.1.2 Vapor Pressure

Vapor pressure is a measure of the volatility of a chemical in its pure state, providing an indication of the rate at which a chemical volatilizes from both soil and water. Vapor pressure is used to calculate the Henry's Law constants. Vapor pressure is of primary significance at environmental interfaces such as surface water/air. Volatilization is not as important when evaluating in situ contaminated groundwater and subsurface soils. Chemicals with high vapor pressures are expected to enter the atmosphere from surface media more readily than those with low vapor pressures. In general, the volatile organics have the highest vapor pressures of all the chemicals detected at the site.

5.1.3 Solubility

The rate at which a chemical is leached from a waste deposit by infiltrating precipitation is in part proportional to its water solubility. More soluble chemicals are more readily leached than less soluble chemicals. The volatile organic chemicals found at the site are highly soluble in comparison to the phthalate esters and polynuclear aromatic hydrocarbons, so the volatile organics are the chemicals that would be expected to be most prevalent in the surface water.

5.1.4 Octanol/Water Partition Coefficient

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (known as the bioconcentration factor) has been determined (Lyman et al. 1990). It is also useful in characterizing the sorption of compounds by organic-rich soils where experimental values are not available.

5.1.5 Organic Carbon Partition Coefficient

The organic carbon partition coefficient (K_{oc}) indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with high organic carbon partition coefficients generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which chemicals are transported in the groundwater or surface water. Chemicals such as the volatile organics are relatively mobile in the environment and migrate in solution (i.e., have low organic carbon partition coefficients) when compared with many of the semivolatile organics, which have high organic carbon partition coefficients and tend to adhere to sediment.

5.1.6 Henry's Law Constant

Henry's Law states that the partial pressure of a chemical above a solution is proportional to its concentration in the solution. The ratio of the vapor pressure to the solubility (the Henry's Law constant) is used to calculate the equilibrium contaminant concentrations in the vapor (air) versus the liquid (water) phases for the dilute solutions generally encountered in environmental settings. In general, chemicals having a Henry's Law constant greater than 5×10^{-6} atm•m^3/mole (such as the volatile organics) would be expected to be found in the atmosphere or soil gas. Chemicals with lower Henry's Law constants would probably be adsorbed to soil.

5.1.7 Bioconcentration Factor

Bioconcentration factors (BCFs) represent the ratio of aquatic animal tissue concentration to the water concentration of a chemical. The ratio is both contaminant- and species-specific. Because site-specific values were not measured, literature values for organics are presented in Table 5-2. Alternatively, the BCF can be derived from the octanol/water partition coefficient. All of the chemicals found at the site are bioaccumulative to some extent, but many of the semivolatile organics are more bioaccumulative than are the volatile organics or metals. BCFs for inorganics are presented in Table 5-1.

5.1.8 Distribution Coefficient

The distribution coefficient (K_d) is a measure of the equilibrium distribution of a chemical or cation in soil/water systems. The distribution of organic chemicals is a function of both the K_{oc} and the amount of organic carbon in the soil. For cations (e.g., metals), K_d is the ratio of the concentration adsorbed on soil surfaces to the concentration in water. K_d for metals varies over several orders of magnitude because the K_d is dependent on the size and charge of the cation and the soil properties governing exchange sites on soil surfaces. Coulomb's Law predicts that the ion with the smallest hydrated radius and the largest charge will be preferentially accumulated over ions with larger radii and smaller charges. K_d for several metals are shown in Table 5-1.

5.1.9 Summary

The distribution of organic and inorganic chemicals in the sediment and surface water in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek is governed primarily by the physical and chemical properties described. However, human intervention (e.g., effluent discharge from man-made facilities) and naturally occurring levels of inorganics also play a role in contaminant distribution and migration.

Organic chemicals were only found in one surface water sample but inorganic chemicals, many of which are naturally occurring, were found in most surface water samples. The organic chemicals generally have high solubilities and low K_{oc}, and are therefore mobile in the surface water, while most inorganics have an affinity for soil and are not very mobile.

Less soluble chemicals such as PAHs, phthalate esters, inorganics, and PCBs were found at low concentrations in sediment samples.

5.2 CONTAMINANT PERSISTENCE

The persistence of several classes of site contaminants is discussed in this section. Several transformation mechanisms affect contaminant persistence such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following general classes of contaminants are discussed:

- Monocyclic aromatics
- Phthalate esters
- Polynuclear aromatics
- Polychlorinated biphenyls
- Inorganics

5.2.1 Monocyclic Aromatics

Monocyclic aromatic compounds, such as xylene, are not considered to be persistent environmental contaminants as are PAHs, phthalate esters, and metals. Such compounds are subject to degradation via the action of both soil and aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent on the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, and so forth.

Although these compounds are amenable to microbial degradation, the rate of degradation cannot be predicted without information on the availability of nutrients and the type of bacteria present. When these contaminants discharge into surface waters, volatilization and biodegradation may occur relatively rapidly. However, chlorinated monocyclic aromatics, such as chlorobenzene, are generally not as susceptible to microbial degradation. For example, a reported first-order biodegradation rate constant for chlorobenzene is 0.0045 day^{-1} in aquatic systems (Lyman et al. 1990), as compared to 0.11 day^{-1} for benzene. This finding corresponds to a half-life of approximately 150 days for chlorobenzene and 6 days for benzene.

Additional degradation processes such as hydrolysis and photolysis are considered to be insignificant fate mechanisms for monocyclic aromatics (U.S. EPA December 1982). However, some monocyclic aromatic compounds, such as benzene and toluene, have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun 1988).

5.2.2 Phthalate Esters

Phthalate esters are considered to be relatively persistent environmental contaminants. Although numerous studies have demonstrated that phthalate esters undergo biodegradation, it appears that this is a very slow process in both soil and surface water. Certain microorganisms have been shown to excrete products that increase the solubility of phthalate esters and enhance their biodegradation (Gibbons and Alexander 1989). Biodegradation of bis(2-ethylhexyl)phthalate and other phthalate esters is an important fate mechanism, as is bioaccumulation. Hydrolysis of phthalate esters is very slow, with calculated half-lives of 3 years (dimethyl phthalate) to 2000 years [bis(2-ethyl-hexyl)phthalate] (U.S. EPA December 1979). Similarly, photolysis is considered to be an insignificant degradation mechanism (U.S. EPA December 1982).

5.2.3 Polynuclear Aromatic Hydrocarbons (PAHs)

PAHs are common constituents of oil and grease. Landspreading applications have indicated that PAHs are amenable to microbial degradation. Studies have demonstrated that PAHs are much more amenable to degradation in soil matrices than in aquatic environments (U.S. EPA December 1979). Under existing site conditions, the rate of microbial degradation cannot be predicted without knowledge of microbial populations. PAHs do not contain functional groups that are susceptible to hydrolytic actions, and hydrolysis is considered to be an insignificant degradation mechanism. Photolysis may be a major degradation mechanism in aquatic environments (U.S. EPA December 1979).

5.2.4 Polychlorinated Biphenyls (PCBs)

PCBs are considered the most persistent organic chemicals detected in Crutcho and Kuhlman Creeks. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded (U.S. EPA December 1979). Although some microorganisms (e.g., Phanaerochaete chrysosporium) may biodegrade PCBs, such fungi may not exist in the creeks. Experimental evidence suggests that heavier PCBs (five chlorines or more per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions (U.S. EPA December 1979). Base-, acid-, and neutral-promoted hydrolysis are considered inconsequential degradation mechanisms for PCBs (U.S. EPA December 1982).

5.2.5 Inorganics

The transport and fate of inorganics in the environment are primarily controlled by sorption to soil/sediment material. The inorganic-organic relationships, both in soil and water, increase in importance as the organic carbon content increases. Some inorganics, such as arsenic, barium, and antimony, are very soluble and mobile in the environment. Many other inorganics, such as nickel, selenium, zinc, and copper, have an affinity for hydrous iron and manganese oxides as well as for organic materials, and are therefore preferentially adsorbed to soil. The mobility of most metals also increases as the soil pH decreases.

5.3 CONTAMINANT MIGRATION ROUTES

The primary contaminant migration mechanism acting at Crutcho and Kuhlman Creeks and the tributaries of Elm Creek is the entry of contaminants into the creeks followed by downstream transport. Contaminants may enter these creeks in three ways: (1) stormwater runoff that erodes contaminated surface media, which reaches the creek via overland flow and/or stormwater drainage facilities; (2) leaching of naturally occurring inorganics from soil and sediment; and (3) discharge of groundwater emanating from contaminated areas (i.e., landfills, fire training areas, JP-4 storage areas, etc.).

Organic contaminants that enter the creek in solution (e.g., volatile organics in groundwater) will be readily transported downstream. Soluble chemicals present in effluent or groundwater which discharge to surface waters are generally more volatile and, therefore, the concentrations will eventually diminish downstream.

Inorganics leached from soil by groundwater or from sediment by surface water will be transported downstream. The inorganics may also sorb or bond to sediment particles and be moved downstream in the sediment matrix. Naturally occurring inorganics, such as barium, will tend to stay in the surface water since the sediment and surrounding soils contain significant levels of barium that can be leached.

Contaminants that enter the creek in runoff (e.g., less soluble chemicals, such as PAHs or phthalate esters) are more likely to be retained by organic carbon in the sediment matrix and be transported downstream via bulk movement of soil material. The larger the sediment particle, the higher flow velocity required to move the particle. Materials with smaller grain size (e.g., clays) also have more exchange sites and are generally higher in organic carbon. Therefore, it is expected that fine-grained

materials containing PAHs, phthalate esters, PCBs, and inorganics may migrate some distance downstream.

6.0 BASELINE RISK ASSESSMENT

6.1 INTRODUCTION

This section presents and discusses the results of the sample-specific risk assessment methodology employed for Kuhlman and Crutcho Creeks and the tributaries of Elm Creek. The objectives of this risk assessment are to determine whether these creeks and tributaries at Tinker AFB present unacceptable public health or environmental risks. The results of the risk assessment can be used to develop appropriate cleanup goals, where necessary, to eliminate or lessen the estimated risks.

To assess public health risks, three major aspects of chemical contamination and environmental fate and transport must be considered: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human activities; (2) potential exposure points must exist; and (3) human or environmental receptors must be present at the point of exposure. No risk is calculated in the absence of toxicity or exposure since risk is defined by these parameters.

The risk assessment estimates the potential for human health risk associated with exposures to sediment and surface water in Kuhlman and Crutcho Creeks, and the tributaries of Elm Creek. Information on the distribution of contamination, the toxicity of the compounds detected in the surface water and sediment, and an estimate of chemical intake via assumed exposure routes are combined to estimate potential risks. The processes used in this assessment are in accordance with current USEPA and informal HAZWRAP guidance (USEPA, December 1989 and March 25, 1991).

A risk assessment consists of four components: (1) data evaluation; (2) toxicity assessment; (3) exposure assessment; and (4) risk characterization. Each of these components are discussed briefly below:

- The Data Evaluation section (Section 6.2) describes the selection of chemicals representative of the type and magnitude of potential human health and/or environmental effects. Contaminant concentrations, contaminant release and environmental transport mechanisms, exposure routes, and toxicity are considered in developing a list of contaminants used to define the associated risks at each sampling location. Background samples are also discussed in this section.

- The Toxicity Assessment (Section 6.3) presents available human health and environmental criteria for all the chemicals of concern. Quantitative toxicity indices are presented when available, including any applicable regulatory standards and criteria. Enforceable standards such as Maximum Contaminant Levels (MCLs), regulatory guidelines such as Ambient Water Quality Criteria (AWQC) and Drinking Water Health Advisories, and dose-response parameters such as Reference Doses (RfDs) and Cancer Slope Factors (CSFs) are presented for each chemical of concern.

- The Exposure Assessment (Section 6.4) identifies potential human health or environmental exposures associated with the creeks. Exposure routes are developed from information on the contaminant concentrations, release mechanisms, patterns of human activity, and other pertinent information.

- The Risk Characterization (Section 6.5) compares the observed concentrations to relevant regulatory standards or guidelines and presents quantitative risk estimates based on intakes and dose-response parameters to define the risks associated with threshold (noncarcinogenic) and nonthreshold (carcinogenic) effects of the chemicals of concern.

Section 6.6 contains a qualitative environmental assessment in which contaminant concentrations are discussed in relation to Oklahoma Water Quality Standards - Draft (Oklahoma Water Resources Board, October 31, 1991). Section 6.7 presents a summary of risks and water quality exceedances and final conclusions.

6.2 DATA EVALUATION

The selection of chemicals of concern is discussed in this section. All contaminants found in the surface waters and sediment were selected if the chemical had published dose-response parameters. Benzo (g,h,i)perylene, phenanthrene, aluminum, calcium, iron, magnesium, potassium, and sodium were the only chemicals detected in the surface water and/or sediment that were not included in the list of chemicals of concern. The inorganic chemicals are nontoxic and are essential human nutrients. Phenanthrene is a relatively nontoxic PAH. Benzo (g,h,i)perylene, also a PAH, is considered to be a Class D carcinogen and no toxicity data are available. The toxicity of PAHs in general is well represented by other similar chemicals in the creek sediments.

Two background samples were collected from Crutcho Creek at Locations B1 and B2 north of Interstate 240 near Sooner Road (Figure 3-1). Reported concentrations in these samples were high for several metals, especially arsenic, barium, and lead; no organics were detected. Naturally occurring

levels of arsenic, barium, and lead have been documented in the soil (USACOE 1990) and the groundwater (USACOE 1988) at Tinker AFB. However, since the background sample locations may have been affected by anthropogenic activity, no contaminants were excluded from the list of chemicals of concern on the basis of comparison to background. The specific chemicals of concern for each of the individual creeks are discussed in the remainder of this section.

6.2.1 Kuhlman Creek

Six locations were sampled in Kuhlman Creek, which is situated in the northern area of Tinker AFB. Surface water and sediment samples were collected at these stations at various times of the year. In addition, a surface water sample was obtained from a catch basin at Location 27. Only two of the creek Locations, 1 and 5, were analyzed for organic parameters. The remaining samples were analyzed for inorganics.

6.2.1.1 Surface Water

Several organic contaminants were detected in the surface water samples collected from Kuhlman Creek. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were found at sample location 1, at maximum concentrations of 6 ug/l and 14 ug/l, respectively. Acetone and 4-methyl-2-pentanone were detected in both samples collected from Kuhlman Creek in May 1992 only (Locations 1 and 5) at maximum concentrations of 32ug/l and 6ug/l. Xylene, which was detected in a sample from Location 5 at a maximum concentration of 4 ug/l, was the only other organic compound detected. The pesticide, chlorpyrifos, was detected in the sample from Location 1 on Kuhlman Creek, with a concentration of 6.1 ug/l. These organic compounds were retained as chemicals of concern.

The seven metals retained as chemicals of concern are listed below:

- arsenic
- barium
- cobalt
- copper
- lead
- selenium
- zinc

Barium and lead were found at varying concentrations in samples from all stations, while copper was only detected in samples from Location 5. The remaining inorganics were found in samples from two or more locations.

6.2.1.2 Sediment

The following is a list of organics retained as chemicals of concern for sediment in Kuhlman Creek:

- fluoranthene
- benzo(a)anthracene
- indeno(1,2,3-cd)pyrene
- chrysene
- benzo(b)fluoranthene
- pyrene
- benzo(a)pyrene
- bis(2-ethylhexyl)phthalate
- di-n-butylphthalate
- Aroclor-1260

Pesticides and PCBs were analyzed only for sample Location 1. The PCB aroclor 1260 was found at a maximum concentration of 167 ug/kg in the sediment sample from this location. Di-n-butylphthalate and indeno(1,2,3-cd)pyrene were detected in samples from Location 1, whereas all of the other compounds were found in samples from Locations 1 and 5. Phenanthrene, detected in a sample from Location 1, was not retained as a chemical of concern as previously discussed.

Eleven inorganics were found in sediment samples as follows:

- antimony
- barium
- chromium (III)
- lead
- mercury
- zinc
- arsenic
- cadmium
- copper
- manganese
- vanadium

The sediment sample from Location 1 contained manganese at a concentration of 522 mg/kg. Antimony, cadmium, and mercury were found in samples from two locations, while the remaining analytes were detected at all sampled locations.

6.2.2 Crutcho Creek

Crutcho Creek is the longest of the three creeks and tributaries investigated. A total of 25 surface water and 22 sediment samples (not counting duplicates separately) were collected from 18 locations along the creek. Five of the sampled locations were analyzed for organic parameters. Samples from all other stations were analyzed for inorganics only.

6.2.2.1 Surface Water

During the most recent sampling event, acetone and 4-methyl-2-pentanone were detected in the two surface water samples collected from Crutcho Creek (at maximum concentrations of 37 ug/l and 7ug/l, respectively). All other contaminants that are of chemicals of concern for Crutcho Creek are inorganics. The chemicals of concern are as follows:

- acetone
- arsenic
- chromium (III)
- copper
- mercury
- zinc
- 4-methyl-2-pentanone
- barium
- cobalt
- lead
- selenium

In general, only a few chemicals were detected in samples from each of the locations. Barium was found in samples from all locations with the highest concentration of 1040 ug/l detected in a sample from Location 15. Many of the locations also contained lead at low concentrations. Chromium, mercury, and selenium were found in samples from only one location each.

6.2.2.2 Sediment

Three organic compounds were selected as chemicals of concern for sediment in Crutcho Creek. Di-n-butylphthalate, bis(2-ethylhexyl)phthalate and 4,4'-DDD were detected at three different locations at maximum concentrations of 400 ug/kg, 75 ug/kg, and 18 ug/kg, respectively.

The following list identifies the inorganic chemicals of concern:

- antimony
- barium
- cadmium
- copper
- manganese
- selenium
- zinc
- arsenic
- beryllium
- chromium (III)
- lead
- mercury
- vanadium

Manganese was detected in sediment samples from five locations with the highest concentration, 1400 mg/kg, found in a sample from Location 16. A sample from Location 6 contained the maximum

concentration of barium (4273 mg/kg). Lead (which was found in all samples) was detected at a maximum concentration of 309 mg/kg in a sample from location 26. The other analytes were detected in samples from two or more sampled locations.

6.2.3 Tributaries of Elm Creek

Four locations were sampled in Elm Creek which is situated southeast of the base's main runway. A total of six surface water and five sediment samples were collected from the three sampling locations.

6.2.3.1 Surface Water

Of all the organic chemicals analyzed, only acetone and 4-methyl-2-pentanone were detected. They were found only during the May 1992 sampling event at concentrations of 18 ug/l and 7ug/l, respectively, in the sample from Location 22A. Both were retained as chemicals of concern. Six of the metals found in Elm Creek were retained as chemicals of concern:

- arsenic
- barium
- cobalt
- copper
- lead
- zinc

Arsenic, barium, and zinc were detected in samples from all locations. Zinc was found at a maximum concentration of 97.1 ug/l in a sample from Location 23. The detected concentrations of arsenic and barium were similar in samples from each location.

6.2.3.2 Sediment

No organics were found in sediment samples collected from Elm Creek. The metals included in the list of chemicals of concern are as follows:

- antimony
- arsenic
- barium
- beryllium
- cadmium
- chromium (III)
- copper
- lead
- manganese
- mercury
- vanadium
- zinc

Manganese and mercury were found only in samples from Location 22 at maximum concentrations of 454 mg/kg and 0.07 mg/kg, respectively. As was the case in Kuhlman Creek, only one sampling location was analyzed for manganese. Antimony and cadmium were detected in samples from one or two sample locations, while the remaining analytes were found in all locations at various concentrations.

6.2.4 Calculation of Average Concentrations

The first step in evaluating the database, which was generated using July 1991, October 1991, February 1992, and May 1992 sampling data, consisted of determining the arithmetic average contaminant concentrations for each location. These average concentrations are assumed to represent an average temporal concentration at that location and were used individually as input in the risk calculations. If a chemical was not detected in one of multiple samples at a specific location, one-half the detection limit was used in the calculating of the average. Otherwise, it was not considered further for that location. In cases where the calculated arithmetic average of a certain contaminant exceeded the maximum detected concentration (as a result of an elevated detection limit), the maximum detected value was used for all subsequent calculations.

6.3 TOXICITY ASSESSMENT

The purpose of this section is to identify the potential health hazards associated with exposure to each of the chemicals of concern. A toxicological evaluation characterizes the inherent toxicity of a compound. The literature indicates that many of the chemicals of concern cause carcinogenic and/or noncarcinogenic health effects in humans. In addition, many of the chemicals have adverse effects on environmental receptors. Although the chemicals of concern may cause adverse health effects, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the intake with the probability of toxic effects, as discussed below.

6.3.1 Health Effects

An important component of the risk assessment process is the relationship between the intake of a chemical (the amount of a chemical that is absorbed by a receptor) and the potential for adverse health effects resulting from that intake. Dose-response relationships provide a means by which potential public health impacts may be quantified. The published information on doses and responses is used in conjunction with information on the nature and magnitude of human exposure to develop an estimate of potential health risks.

RfDs and/or CSFs have been developed by the USEPA for many organic and inorganic chemicals. This section provides a brief description of these parameters.

6.3.1.1 Reference Doses (RfDs)

The RfD is developed by the USEPA for chronic and/or subchronic human exposure to hazardous chemicals and is solely based on the noncarcinogenic health effects imparted by a chemical. The RfD is usually expressed as a dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a non-observed-(adverse)-effect-level (NOEL or NOAEL) or a lowest-observed-adverse-effect-level (LOAEL) by an appropriate uncertainty factor. NOAELs and LOAELs are determined from laboratory or epidemiological toxicity studies. The uncertainty factor is based on the availability of toxicity data.

Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the available data. A factor of 10 is used to account for variations in the general population (to protect sensitive subpopulations), when extrapolating test results from animals to humans (to account for interspecies variability), when a NOAEL derived from a subchronic study (instead of a chronic study) is used to develop the RfD, and when a LOAEL is used instead of a NOAEL. In addition, the USEPA reserves the use of a modifying factor of up to 10 for professional judgment of uncertainties in the database not already accounted for by the uncertainty factors. The default value of the modifying factor is 1.0.

The RfD incorporates the surety of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as diminished by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus the RfD is an acceptable guideline for the evaluation of noncarcinogenic risk, although the associated uncertainty precludes its use for precise risk quantitation.

6.3.1.2 Cancer Slope Factor (CSF)

CSFs are applicable for estimating the lifetime probability (assuming a 70-year lifetime) of human receptors developing cancer as a result of exposure to known or potential carcinogens. This factor is generally reported by the USEPA in units of $(mg/kg/day)^{-1}$, and is derived through an assumed low-dosage linear relationship and an extrapolation from high to low dose responses determined from animal studies. The value used in reporting the CSF is the upper 95 percent confidence limit.

6.3.1.3 Weight of Evidence

The weight of evidence designations of chemicals indicate the likelihood that a chemical is a human carcinogen, based on both animal and human studies. The classification is as follows:

A = Known human carcinogen.

B = Potential human carcinogen. B1 indicates that limited human data are available. B2 indicates that there is sufficient evidence of carcinogenicity in animals but inadequate or no evidence in humans.

C = Possible human carcinogen.

D = Not classifiable as to human carcinogenicity.

E = No evidence of carcinogenicity in humans.

6.3.2 Applicable, or Relevant and Appropriate Requirements (ARARs)

The available regulatory standards or guidelines for the chemicals of concern in Kuhlman and Crutcho Creeks and tributaries for Elm Creek are presented in this section. Currently, the only enforceable Federal regulatory standards for exposure to contaminants in drinking water are the MCLs. However, no MCLs have been determined for many of the chemicals of concern and therefore other regulatory guidelines may be used to infer human health risks. Relevant regulatory guidelines include AWQC, MCLGs, Oklahoma Water Quality Standards, and USEPA Drinking Water Health Advisories.

AWQC are the criteria most often associated with the evaluation of potential impacts on aquatic life. Where the state has not adopted chemical-specific criteria, the Federal criteria may apply.

6.3.2.1 Maximum Contaminant Levels (MCLs)

MCLs are enforceable standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 kg) who consumes 2 liters of water per day, but they also reflect the technical feasibility of removing a contaminant from the water. These enforceable standards also reflect the fraction of toxicant expected to be absorbed by the gastrointestinal tract on ingestion.

None of the creeks under consideration are currently used as a primary source of drinking water. Hence, the MCLs are not strictly applicable but are useful for comparative purposes.

6.3.2.2 Maximum Contaminant Level Goals (MCLGs)

MCLGs are generally specified as zero for carcinogenic chemicals, based on the assumption of nonthreshold toxicity, and do not consider either the technical or economic feasibility of achieving these goals. MCLGs are nonenforceable guidelines based solely on health effects. The MCLs are set as close to the MCLGs as considered technically and economically feasible.

6.3.2.3 Ambient Water Quality Criteria (AWQC)

AWQC are nonenforceable Federal regulatory guidelines, and are of primary utility in assessing the potential for toxic effects in aquatic organisms. The guidelines may also be used to identify the potential for human health risks. AWQCs consider both the acute and toxic effects from ingestion of both water (2 l/day) and aquatic organisms (6.5 g/day), and from ingestion of water alone. The AWQCs for protection of human health for carcinogenic substances are based on the USEPA's specified incremental cancer risk range of 1 additional case of cancer in an exposed population of 10,000,000 to 100,000 persons and may be based on outdated toxicologic data.

6.3.2.4 USEPA Drinking Water Health Advisories

Health Advisories are guidelines developed by the USEPA Office of Drinking Water for nonregulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (with an assumed body weight of 10 kg) who consume 1 liters of water per day, or in adults (with an assumed body weight of 70 kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1-day), subchronic (10-day), and chronic (longer-term or lifetime) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels for known or probable human carcinogens.

6.3.2.5 Oklahoma Water Quality Standards

The State of Oklahoma has regulations governing the amounts and types of environmental pollutants that can exist in drinking water, public and private water supplies, surface water, and groundwater. Currently, the Oklahoma Water Resources Board, Water Quality division, is revising the Water Quality Standard. This proposed standard, dated October 1991, is being revised to reflect human health criteria.

6.3.2.6 Summary

Table 6-1 presents the values of the available Federal ARARs and dose-response parameters for both carcinogenic and noncarcinogenic chemicals of concern. The ARARs will be used for comparative purposes and the dose-response parameters will be used for quantitative risk estimation using potential intakes. A comparison of observed chemical of concern concentrations and Oklahoma Water Quality Standards is presented in Section 6.6. Expected intakes of each chemical of concern are calculated in the following section.

6.4 EXPOSURE ASSESSMENT

The purpose of this section is to evaluate the potential for human exposure to the hazardous chemicals detected in the surface water and sediment at the sampled locations of Kuhlman and Crutcho Creeks and tributaries of Elm Creek. This section identifies actual or potential exposure routes and provides exposure estimates. The nature and extent of contamination on which the exposures are based was presented in Section 4.0 (Nature and Extent of Contamination).

To determine whether there is an actual or potential exposure at a specific sampling location, the most likely human and environmental activity patterns must be considered. Contaminants have been found in both the surface water and the sediment at every sampling location of Kuhlman and Crutcho Creeks and tributaries of Elm Creek. Receptors can come into direct contact with these media, thereby completing an exposure pathway.

6.4.1 Exposure Routes

Receptors can be exposed to location-specific contaminants in two environmental media (surface water and sediment), which are addressed in this section. Exposure routes include dermal contact and ingestion.

6.4.1.1 Surface Water

Elm Creek flows to a reservoir that is used as a potable water supply. While Kuhlman and Crutcho Creeks are not used as potable water supplies, there are no restrictions against such use. Therefore, exposure to surface water contaminants could occur via ingestion under a worst-case exposure scenario. Additional exposure routes such as inhalation and dermal contact for this purely hypothetical exposure scenario are not considered at this time.

TABLE 6-1

REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Chemical	Safe Drinking Water Act (mg/l)[1][2]		Health Advisory (mg/l)[3]	Reference Dose (mg/kg/day)[4]		Cancer Slope Factor (mg/kg/day)$^{-1}$ [4][5]		Weight of Evidence [3][4][5]	Ambient Water Quality Criteria (mg/l)[12]	
	MCL	MCLG		Oral	Inhalation	Oral	Inhalation		Water and Fish	Fish Only
Acetone				1×10^{-1}				D		
4-Methyl-2-pentanone				5×10^{-2}				D		
Xylenes	10	10	1-Day/Child: 40 10-Day/Child: 40 Longer-Term/Child: 40 Longer-Term/Adult: 100 Lifetime/Adult: 10	2×10^{0}	9×10^{-2}**			D		
Bis(2-ethylhexyl)phthalate	0.006	0		2×10^{-2}		1.4×10^{-2}		B2	1.8×10^{-3}	5.9×10^{-3}
Di-n-butylphthalate				1×10^{-1}				D	2.7×10^{0}	1.2×10^{1}
Di-n-octylphthalate				2×10^{-2}						
Benzo(a)anthracene	0.0001*	0*				1.1×10^{0}	8.8×10^{-1}	B2	2.8×10^{-6}	3.11×10^{-5}
Benzo(b)fluoranthene	0.0002*	0*				1.0×10^{0}	8.5×10^{-1}	B2	2.8×10^{-6}	3.11×10^{-5}
Benzo(a)pyrene	0.0002	0				7.3×10^{0}	6.1×10^{0}**	B2	2.8×10^{-6}	3.11×10^{-5}
Chrysene	0.0002*	0*				3.2×10^{-2}	2.7×10^{-2}	B2	2.8×10^{-6}	3.11×10^{-5}
Fluoranthene				4×10^{-2}					3.0×10^{-1}	3.7×10^{-1}
Indeno(1,2,3-cd)pyrene	0.004*	0*				1.7×10^{0}	1.4×10^{0}	B2	2.8×10^{-6}	3.11×10^{-5}
Pyrene				3×10^{-2}				D	9.6×10^{-1}	1.1×10^{1}
4,4'-DDD						2.4×10^{-1}		B2	8.3×10^{-7}	8.4×10^{-7}
Chlorpyrifos				3×10^{-3}						
Aroclor	0.0005	0				7.7×10^{0}		B2	4.4×10^{-8}	4.5×10^{-8}
Antimony	0.006	0.006	1-Day/Child: 0.015 10-Day/Child: 0.015 Longer-Term/Child: 0.015 Longer-Term/Adult: 0.015 Lifetime/Adult: 0.003	4×10^{-4}				D	1.4×10^{-2}	4.3×10^{0}

TABLE 6-1
REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Chemical	Safe Drinking Water Act (mg/l)[1][2]		Health Advisory (mg/l)[3]	Reference Dose (mg/kg/day)[4]		Cancer Slope Factor (mg/kg/day)$^{-1}$ [4][5]		Weight of Evidence [3][4][5]	Ambient Water Quality Criteria (mg/l)[12]	
	MCL	MCLG		Oral	Inhalation	Oral	Inhalation		Water and Fish	Fish Only
Arsenic	0.05			3×10^{-4}		1.8×10^{0}[13]	5×10^{1}	A	1.8×10^{-5}	1.4×10^{-4}
Barium	2.0	2.0	Lifetime/Adult: 2.0	7×10^{-2}	1×10^{-4}**			D		
Beryllium	0.004	0.004	1-Day/Child: 30.0 10-Day/Child: 30.0 Longer-Term/Child: 4.0 Longer-Term/Adult: 20.0	5×10^{-3}		4.3×10^{0}	8.4×10^{0}	B2	7.7×10^{-6}	1.3×10^{-4}
Cadmium	0.005	0.005	1-Day/Child: 0.04 10-Day/Child: 0.04 Longer-Term/Child: 0.005 Longer-Term/Adult: 0.02 Lifetime/Adult: 0.005	5×10^{-4}			6.1×10^{0}	B1	1.6×10^{-2}	1.7×10^{-1}
Chromium (III)	0.1	0.1	1-Day/Child: 1.0 10-Day/Child: 1.0 Longer-Term/Child: 0.2 Longer-Term/Adult: 0.8 Lifetime/Adult: 0.1	1×10^{0}	6×10^{-7}**			D	3.3×10^{1}	6.7×10^{2}
Cobalt				8×10^{-3} [7]						
Copper	1.3 [9]	1.3		4×10^{-2}				D	1.3 $\times 10^{0}$	
Lead	0.015 [9]	0		1.4×10^{-3} [10]	4.3×10^{-4} [10]			B2	5.0×10^{-2}	
Manganese		0.05[11]		1×10^{-1}	1×10^{-4}					
Mercury	0.002	0.002	Longer-Term/Adult: 0.002 Lifetime/Adult: 0.002	3×10^{-4}**	9×10^{-5}**			D	1.4×10^{-4}	1.5×10^{-4}
Selenium	0.05	0.05		5×10^{-2} [8]					1.0×10^{-1}	6.8×10^{0}
Vanadium			1-Day/Child: 0.08 10-Day/Child: 0.08 Longer-Term/Child: 0.03 Longer-Term/Adult: 0.11 Lifetime/Adult: 0.02	7×10^{-3}				D		

BLE 6-1
REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Chemical	Safe Drinking Water Act (mg/l)[1][2]		Health Advisory (mg/l)[3]	Reference Dose (mg/kg/day)[4]		Cancer Slope Factor (mg/kg/day)$^{-1}$ [4][5]		Weight of Evidence [3][4][5]	Ambient Water Quality Criteria (mg/l)[12]	
	MCL	MCLG		Oral	Inhalation	Oral	Inhalation		Water and Fish	Fish Only
Zinc	5.0 [11]		1-Day/Child: 4.0 10-Day/Child: 4.0 Longer-Term/Child: 2.0 Longer-Term/Adult: 9.0 Lifetime/Adult: 2.0	2×10^{-1}				D		

* Proposed.
** Under review; Value presented is the most recent published value
(1) Safe Drinking Water Act, 40 CFR 141/142/143; U.S. EPA, July 17, 1992.
(2) US EPA, July 25, 1990.
(3) US EPA, April 1992.
(4) IRIS on-line.
(5) ICF- Clement Associates, April 1, 1988.
(6) US EPA, October 1986.
(7) Calculated from LD_{LO}.
(8) Calculated from TD_{LO}.
(9) Action level (US EPA, June 7, 1991)
(10) RfD has been revoked pending review of carcinogenicity.
(11) Secondary MCL.
(12) EPA 1991
(13) Based on drinking water unit risk (IRIS)

Incidental ingestion and dermal absorption scenarios were also evaluated in this risk assessment since it is possible that local adolescents could play in the creeks and tributaries and consequently come in contact with contaminated surface water.

Kuhlman, and Crutcho Creeks, tributaries of Elm Creek support various forms of aquatic life. Although subsistence fishing in the creeks and tributaries is not likely, long-term recreational fishing is possible, constituting a potential exposure route through fish ingestion.

6.4.1.2 Sediment

Exposure to sediment in the creeks would most likely be incurred by adolescents playing in the area. It is unlikely that adults would actively wade in the creek when they can fish from the banks. As with exposure to surface water, exposure to sediment could occur through incidental ingestion or dermal contact.

6.4.2 Exposure Estimates

The estimation models and methods used in this section are based on current USEPA risk assessment guidance (USEPA, December 1989 and March 25, 1991) and informal guidance from HAZWRAP. Exposure estimation methods associated with each exposure route are described in the remainder of this section. All exposure scenarios incorporate the specific sample location concentrations in the estimation of intakes.

The exposure concentration is considered to be the arithmetic average contaminant concentration at each measurement station. This concentration is intended to be representative of the long-term average concentration at any given location, recognizing the limited database available.

Noncarcinogenic risks are estimated by using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. The intake is used with a term known as the averaging time, which converts the daily exposure frequency and duration to an annual exposure by dividing by 365 days per year of exposure. Intakes may be greater for children than for adults because of children's lower body weight.

Carcinogenic risks, however, are calculated as an incremental lifetime risk and, therefore, incorporate terms to represent the exposure duration over the course of a lifetime (70 years, or 25,550 days). Carcinogenic risks may not be calculated for small children or adolescents if adults are

also being assessed, because the risks to children are generally lower as a result of their shorter exposure duration.

6.4.2.1 Surface Water Ingestion

The first potential exposure route associated with surface water exposure is future potable use of the surface water by local residents. This exposure route is not likely to occur given the irregular upstream flow of the creeks and the ready availability of groundwater/public water supplies, except where the creeks flow into a larger stream or lake used as a water supply. Dilution of the surface water flowing from Tinker AFB by these larger streams was not included in the worst-case ingestion exposure scenario. Other typical potable water exposure scenarios, such as inhalation and dermal contact during showering, were not evaluated.

Ingestional exposures are characterized using the following expression (USEPA December 1989):

$$IEX = C \times IR \times EF \times ED / (BW \times AT)$$

where

- IEX = ingestional exposure dose (mg/kg/day)
- C = exposure concentration (mg/l)
- IR = ingestion rate (l/day)
- EF = exposure frequency (days/year)
- ED = exposure duration (years)
- BW = body weight (kg)
- AT = averaging time or period of exposure (days)

Under the potable use scenario, the following input parameters are used to estimate intakes. Adult residents are assumed to ingest 2 liters of water per day, 350 days per year, over a 30-year exposure duration (USEPA, December 1989 and March 25, 1991). Child residents are assumed to ingest 1 liter of water per day, 350 days per year. Body weights are specified as 70 kg for adults and 15 kg for small children.

The complete list of input parameters for this potential exposure route is presented in Table 6-2.

TABLE 6-2

EXPOSURE ASSESSMENT SUMMARY – INGESTION
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Ingestion of Surface Water (Residents)			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	Specific sampling station concentration (mg/l)	Professional judgment
IR	Ingestion Rate	Adult: 2 liter/day Child: 1 liter/day	Convention; EPA guidance (US EPA, December 1989)
EF	Exposure Frequency	350 days/year	EPA guidance (US EPA, March 25, 1991)
ED	Exposure Duration	Adult: 30 years Child: 6 years	90th percentile at one residence (US EPA, December 1989; March 25, 1991)
BW	Body Weight	Adult: 70 kg Child: 15 kg	Convention; EPA guidance (US EPA, December 1989; March 25, 1991)
AT	Averaging Time	30 years x 365 days/year 70 years x 365 days/year 6 years x 365 days/year	Adult - Noncarcinogens Adult - Carcinogens Child - Noncarcinogens

6.4.2.2 Recreational Exposure to Surface Water

Exposure to surface water could occur if adolescent residents play in the area. Both dermal contact and incidental ingestion are assumed to occur. The equation used to calculate ingestional intakes is the same as that presented for surface water ingestion under the potential potable use scenario. All exposures to surface water were estimated using the actual contaminant concentrations for each sampling station.

The following input parameters were used to evaluate incidental ingestion of surface water during play. It is assumed that ingestion would occur at the rate of 0.05 l/hour, and that the exposure time is 2.6 hours/day (USEPA December 1989). Exposures are assumed to occur at a frequency of 14 days per year at any given station between the ages of 8 and 16 (9 years). These receptors are assumed to weigh an average of 40 kg over this age range (USEPA May 1989).

Dermal exposure during recreation is evaluated using the following expression (USEPA December 1989):

$$DEX = C \times SA \times PC \times ET \times EF \times ED / (BW \times AT \times 10^3)$$

where

DEX = dermal exposure dose (mg/kg/day)
C = surface water exposure concentration (mg/l)
SA = skin surface area available for contact (cm^2)
PC = dermal permeability constant of water (cm/hour)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time or period of exposure (days)
10^3 = conversion factor (cm^3/l)

This approach is based on the assumption that surface water contaminants are present in dilute solution and that percutaneous absorption is controlled by the flux of water. The permeability constant of water is 1.0×10^{-3} cm/hour (USEPA January 1992). Skin surface area available for contact is specified as 13,700 cm^2, assuming whole body contact (USEPA May 1989). This is the 50th percentile average body surface area for males ages 8 to 16.

The exposure time was set at 2.6 hours per day, and the exposure frequency was set at 14 days per year at any one sampling location. Exposures are estimated to occur over a 9-year period from the ages of 8 to 16. Body weight was specified as 40 kg over this age range (USEPA May 1989). All exposure parameters for this exposure route are summarized in Table 6-3.

6.4.2.3 Recreational Exposure to Sediment

Adolescents playing in Kuhlman, Crutcho, and Elm Creeks could also be exposed to sediment contaminants. Adult exposure would probably not occur for the reasons outlined earlier.

Direct contact with sediment in the creeks and tributaries can result in both dermal and incidental ingestional exposure (after hand-to-mouth contact). Sediment ingestion is estimated using the following equation (USEPA December 1989):

$$IEX = C \times IR \times FI \times EF \times ED \times 10^{-6} / (BW \times AT)$$

where

IEX	=	ingestional exposure dose (mg/kg/day)
C	=	exposure concentration (mg/kg)
IR	=	ingestion rate (mg/day)
FI	=	fraction ingested from creek (dimensionless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
10^{-6}	=	conversion factor (kg/mg)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)

It was assumed that 50 percent of an adolescent's daily soil intake (100 mg/day) would occur while playing in the creeks. As with the surface water exposures, exposure is assumed to occur 14 days per year in any one segment, over a period of nine years (between the ages of 8 and 16).

TABLE 6-3

EXPOSURE ASSESSMENT SUMMARY – RECREATION
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Incidental Ingestion of Surface Water (Adolescents)			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	Specific sampling station concentration (mg/l)	Professional judgment
IR	Ingestion Rate	0.05 liter/hour	US EPA, December 1989
ET	Exposure Time	2.6 hour/day	US EPA, April 1988
EF	Exposure Frequency	14 days/year	Professional judgment
ED	Exposure Duration	9 years	Ages 8 to 16; professional judgment
BW	Body Weight	40 kg	Average, ages 8 to 16 (US EPA, May 1989)
AT	Averaging Time	9 years x 365 days/year 70 years x 365 days/year	Noncarcinogens Carcinogens

TABLE 6-3
EXPOSURE ASSESSMENT SUMMARY – RECREATION
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE TWO

Dermal Contact with Surface Water (Adolescents)			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	Specific sampling station concentration (mg/l)	Professional judgment
SA	Exposed Surface Area of Skin Available for Contact	13,700 cm^2	50th percentile average, ages 8 to 16 (US EPA, May 1989)
PC	Dermal permeability Constant	1 x 10^{-3} cm/hour	Flux controlled by permeation of water (US EPA, January 1992)
ET	Exposure Time	2.6 hours/day	US EPA, April 1988
EF	Exposure Frequency	14 days/year	Professional judgment
ED	Exposure Duration	9 years	Ages 8 to 16; professional judgment
BW	Body Weight	40 kg	Average, ages 8 to 16 (US EPA, May 1989)
AT	Averaging Time	9 years x 365 days/year 70 years x 365 days/year	Noncarcinogens Carcinogens

TABLE 6-3
EXPOSURE ASSESSMENT SUMMARY - RECREATION
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE THREE

Incidental Ingestion of Sediment (Adolescents)			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	Specific sampling station concentration (mg/kg)	Professional judgment
IR	Ingestion Rate	100 mg/day	EPA Guidance (US EPA, December 1989)
FI	Fraction Ingested from creek segment	0.50	Professional judgment
EF	Exposure Frequency	14 days/year	Professional judgment
ED	Exposure Duration	9 years	Ages 8 to 16; professional judgment
BW	Body Weight	40 kg	Average, ages 8 to 16 (US EPA, May 1989)
AT	Averaging Time	9 years x 365 days/year 70 years x 365 days/year	Noncarcinogens Carcinogens

TABLE 6-3
EXPOSURE ASSESSMENT SUMMARY - RECREATION
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
PAGE FOUR

Dermal Contact with Sediment (Adolescents)			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	Specific sampling station concentration (mg/kg)	Professional judgment
SA	Exposed Surface Area of Skin Available for Contact	8,500 cm^2	50th percentile area of forearms, hands, lower legs and feet, ages 8 to 16 (US EPA, May 1989)
AF	Soil-to-skin adherence factor	1.0 mg/cm^2	Value for commercial potting soil (US EPA, January 1992)
ABS	Absorption factor (dimensionless)	Volatiles: 0.10 Semivolatiles/ Pesticides: 0.05 PCBs: 0.03 Metals: 0.0	Accounts for desorption from soil and percutaneous absorption (Feldman & Maibach, 1970; Wester & Maibach, 1985; US EPA, May 1986)
EF	Exposure Frequency	14 days/year	Professional judgment
ED	Exposure Duration	9 years	Ages 8 to 16; professional judgment
BW	Body Weight	40 kg	Average, ages 8 to 16 (US EPA, May 1989)
AT	Averaging Time	9 years x 365 days/year 70 years x 365 days/year	Noncarcinogens Carcinogens

The following equation is used to calculate dermal exposure to sediment (USEPA December 1989):

$$DEX = C \times SA \times AF \times ABS \times EF \times ED \times 10^{-6} / (BW \times AT)$$

where

DEX	=	dermal exposure dose (mg/kg/day)
C	=	exposure concentration (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	soil-to-skin adherence factor (mg/cm^2)
ABS	=	absorption factor (dimensionless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
10^{-6}	=	conversion factor (kg/mg)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)

Dermal contact with sediment is estimated to occur over a body surface area of 8500 cm^2, which is the 50th percentile area of the forearms, hands, lower legs, and feet of males ages 8 to 16 (USEPA May 1989). Soil adheres to the skin at a rate of 1.0 mg/cm^2 (USEPA January 1992). The absorption of organics was assumed as follows:

- Volatiles 0.10
- Semivolatiles 0.05
- Pesticides 0.05
- PCBs 0.03

Metals in soil are not assumed to be dermally absorbed to any measurable extent. Exposure frequencies, duration, body weight, and so forth are the same as those used for the surface water ingestion and dermal contact scenarios. The input parameters for the sediment exposure routes are also summarized in Table 6-3.

6.4.2.4 Fish Ingestion

Local residents could catch and consume fish from the creeks and tributaries, thereby being indirectly exposed to surface water contaminants accumulated in the tissues of aquatic biota. Intakes via fish

ingestion are estimated as follows (USEPA December 1989):

$$IEX = C \times IR \times FI \times EF \times ED \times 10^{-6} / (BW \times AT)$$

where

IEX	=	ingestional exposure dose (mg/kg/day)
C	=	fish tissue concentration (mg/kg)
IR	=	ingestion rate (kg/day)
FI	=	fraction ingested from Tinker AFB Creeks (dimensionless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
10^{-6}	=	conversion factor (kg/mg)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)

The concentration in fish tissue was calculated from the surface water concentrations and the bioconcentration factors reported in Table 5-1. It was assumed that a recreational adult fisherman will ingest an average of 54 g/day of fish and that 50 percent of that amount will come from the local creeks (USEPA March 1991). This is a conservative (worst-case) intake assumption considering the size of fish present in the creeks at Tinker AFB, and exceeds the national average per capita consumption rate of 6.5 g/day. Exposure duration is assumed to be 30 years for a 70-kg adult. Table 6-4 presents the intake parameters for this exposure route.

6.5 RISK CHARACTERIZATION

Potential human health risks resulting from the exposures outlined in the preceding section are characterized on a quantitative and qualitative basis in this section. Quantitative risk estimates are generated based on risk assessment methods outlined in the current USEPA guidance (USEPA December 1989 and March 25, 1991). The qualitative assessment consists of a comparison of measured concentrations to standards or guidelines.

Noncarcinogenic risk estimates are presented in the form of Hazard Quotients and Hazard Indices that are determined by the comparison of estimated intakes with published Reference Doses. Incremental cancer risks are provided in the form of dimensionless probabilities based on Cancer Slope Factors.

TABLE 6-4

EXPOSURE ASSESSMENT SUMMARY – FISH INGESTION
CRUTCHO AND KUHLMAN CREEKS AND TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Ingestion of Finfish (Adult Residents)			
Input Parameter	Description	Value	Rationale
C	Surface Water Concentration	Specific sampling station concentration (mg/l)	Professional judgment
BCF	Bioconcentration Factor	Chemical-specific (mg/l/mg/kg)	
IR	Ingestion Rate	54 g/day	US EPA, March 1991
FI	Fraction Ingested from Tinker AFB Creeks	0.5	Professional judgment
EF	Exposure Frequency	365 days/year	Daily intake
ED	Exposure Duration	30 years	90th percentile at one residence (US EPA, December 1989;
BW	Body Weight	70 kg	Convention (US EPA, December 1989)
AT	Averaging Time	30 years x 365 days/year 70 years x 365 days/year	Noncarcinogens Carcinogens

Estimated human intakes were developed for each of the specific exposure routes discussed in the preceding section. Both carcinogenic and noncarcinogenic risks are summarized for each exposure route in a series of tables in this section. Detailed calculations are provided in Appendix G.

Noncarcinogenic risk is assessed by using the concept of Hazard Quotients and Hazard Indices. The Hazard Quotient is the ratio of the estimated intake and the RfD for a selected chemical of concern, as follows:

$$\text{Hazard Quotient} = \text{Intake} / \text{RfD}$$

A Hazard Index is generated by summing the individual Hazard Quotients for all chemicals of concern. If the value of the Hazard Index exceeds unity (1.0), there is a potential noncarcinogenic health risk associated with exposure to that particular chemical mixture (USEPA, September 24, 1986). At that time, particular attention should be paid to the target organs affected by each chemical. The Hazard Index is not a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of the possibility of occurrence of noncarcinogenic (threshold) effects. If the ratio of the intake and the RfD for any individual chemical exceeds unity, then toxic effects are possible.

Incremental cancer risk estimates are generated for each of the exposure pathways by using the estimated intakes and published CSFs, as follows:

$$\text{Risk} = \text{Intake} \times \text{CSF}$$

If the above equation results in a risk greater than 0.1, the following equation is used:

$$\text{Risk} = 1 - [\exp(-\text{Intake} \times \text{CSF})]$$

The risk calculated by using these equations is a unitless expression of an individual's likelihood of developing cancer as a result of exposure to carcinogenic chemicals. An incremental cancer risk of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million incremental chance of developing cancer. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons. The calculated incremental cancer risk should be recognized as an upper-bound estimate. Cancer Slope Factors are the upper 95 percent confidence limit of a dose-response curve generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on CSFs, and, in fact, may be lower.

The USEPA has generally defined carcinogenic risks in the range of 10^{-4} to 10^{-6} as being acceptable for most hazardous waste facilities addressed under CERCLA. For CERCLA activities, residual risks on the order of 10^{-6} are the primary goal but are often modified by such regulatory requirements as MCLs or chemical-specific cleanup goals. Under the proposed Subpart S of RCRA Part 264, the USEPA has proposed that residual carcinogenic risks not exceed 10^{-4} for all chemicals in combination, with the risk from any individual chemical not to exceed 10^{-6}.

Carcinogenic and noncarcinogenic health risks are estimated using a number of assumptions; therefore, the values presented in this section contain an inherent amount of uncertainty. The extent to which health risks can be characterized is primarily dependent on the accuracy with which the toxicity of a chemical can be estimated and the accuracy of the exposure scenario assumptions. The toxicologic data that form the basis for all risk assessments contain uncertainty in the following areas:

- The extrapolation of nonthreshold (carcinogenic) effects from the high doses administered to laboratory animals to the low doses received under more common human exposure scenarios.

- The extrapolation of the results of laboratory animal studies to human or environmental receptors.

- The interspecies variation in toxicologic endpoints used in characterizing potential health effects resulting from exposure to a chemical.

- The variations in sensitivity among individuals of any particular species.

In addition to these sources of uncertainty, the exposure estimates presented in Section 6.4 are also based on a number of simplifying assumptions. The assumptions made include the following:

- Receptor characteristics such as age, body weight, and exposure duration, with attempts to make them more appropriate for land use at the base.

- Land use and activity patterns in the area are limited to the observations made during the field investigation and known land uses in the surrounding area, with some speculation regarding specific receptor types.

- There are no antagonistic or synergistic relationships between chemicals of concern.

Long-term average concentrations were used in the risk calculations because more than one round of sampling was performed.

6.5.1 Surface Water Exposure

A location-specific summary of the risks associated with exposure to surface water are presented in this section. Appendix G contains the chemical-specific risks per sampling location.

6.5.1.1 Local Residents via Ingestion

Hazard Indices and incremental cancer risks associated with the direct ingestion of surface water by local residents are defined in Table 6-5.

Kuhlman Creek

Hazard Indices for all locations, except for child residents (1.2×10^{0}) at Locations 2 and 4, were below unity. Lead was the largest contributor to the risks associated with Location 27, and barium was the most significant at every other location (52 percent of the Hazard Index at Location 2).

It should be noted that barium sulfate reportedly occurs naturally in the vicinity of Tinker AFB and that barium is not known to have been used at the facility. Therefore, it is considered likely that the noncarcinogenic risks associated with barium are indicative of naturally occurring conditions.

Furthermore, it is important to note that the three major contributors to the Hazard Index at all of the sampling locations are arsenic, barium, and lead. These inorganic elements have distinctly different toxic effects, as follows (USEPA January 1991):

- arsenic - Keratosis and hyperpigmentation
- barium - Fetotoxicity and increased blood pressure
- lead - Central nervous system effects

As per current EPA guidance, to arrive at a truly representative Hazard Index, the toxic endpoints of the individual chemicals should be considered and only those with similar effects should be treated additively. Therefore, since the effects are markedly dissimilar for these three chemicals, it is concluded that the Hazard Indices slightly greater than 1.0 (e.g., 1.2) are not indicative of potential adverse health effects even under the conservative exposure assumptions used for this analysis.

TABLE 6-5

HAZARD INDICES AND INCREMENTAL CANCER RISKS[1]
SURFACE WATER EXPOSURES - RESIDENTS VIA INGESTION
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sampling Station[2]	Adult Resident		Child Resident
	Hazard Index	Incremental Cancer Risk	Hazard Index
KUHLMAN CREEK			
SW01	3.8×10^{-1}	8.9×10^{-7}	8.9×10^{-1}
SW02	5.3×10^{-1}	----	**1.2×10^{0}**
SW03	2.9×10^{-1}	----	6.8×10^{-1}
SW04	5.1×10^{-1}	----	**1.2×10^{0}**
SW05	2.7×10^{-1}	----	6.4×10^{-1}
SW27	2.8×10^{-1}	----	6.6×10^{-1}
CRUTCHO CREEK			
SW06	5.7×10^{-1}	----	**1.3×10^{0}**
SW07	4.8×10^{-1}	----	**1.1×10^{0}**
SW08	5.5×10^{-1}	----	**1.3×10^{0}**
SW09	4.9×10^{-1}	----	**1.2×10^{0}**
SW10	5.1×10^{-1}	----	**1.2×10^{0}**
SW11	2.3×10^{-1}	----	5.5×10^{-1}
SW12	2.6×10^{-1}	----	6.1×10^{-1}
SW13	5.4×10^{-1}	----	**1.3×10^{0}**
SW14	3.3×10^{-1}	----	7.8×10^{-1}
SW15	4.8×10^{-1}	----	**1.1×10^{0}**
SW16	3.8×10^{-1}	----	8.8×10^{-1}
SW17	2.7×10^{-1}	----	6.2×10^{-1}
SW18	2.3×10^{-1}	----	5.3×10^{-1}
SW19	3.2×10^{-1}	----	7.4×10^{-1}
SW20	1.7×10^{-1}	----	4.0×10^{-1}
SW21	1.9×10^{-1}	----	4.3×10^{-1}
SW25	3.3×10^{-1}	----	7.6×10^{-1}
SW26	1.2×10^{-1}	----	2.8×10^{-1}
ELM CREEK			
SW22	3.4×10^{-1}	----	7.8×10^{-1}
SW23	2.6×10^{-1}	----	6.2×10^{-1}
SW24	3.0×10^{-1}	----	7.1×10^{-1}

(1) Hazard Quotients and Incremental Cancer Risks for specific chemicals presented in Appendix G.
(2) SW - Indicates surface water sample.

An incremental cancer risk of 8.9 x 10^{-7} was estimated for adult residents at Location 1. Bis(2-ethylhexyl)phthalate at an average concentration of 5.4 ug/l was the sole source of the risk, which was below the USEPA risk goal (10^{-6}). No other locations have calculated risks since no cancer slope factors are available for the specific contaminants. However, recent information obtained in IRIS indicates that a unit risk is available for ingested inorganic arsenic, but that the associated uncertainty is an order of magnitude or more. At this time, therefore, arsenic will not be considered as a carcinogen via ingestion. Cancer risks are not calculated for child residents as indicated in the discussion of exposure estimates.

Crutcho Creek

Hazard Indices for child residents at Locations 6, 7, 8, 9, 10, 13, and 15 exceed unity. The primary contributors to this risk are arsenic, barium, and lead. No adverse noncarcinogenic health effects are predicted for child residents at the remaining locations or for adult residents at any location since all associated Hazard Indices were less than 1.0. The discussion of barium sulfate and toxic endpoints discussed for Kuhlman Creek also apply to Crutcho Creek. Therefore, the Hazard Indices slightly greater than 1.0 are not indicative of potential adverse health effects.

Only acetone, 4-methyl-2-pentanone, and various inorganics were found in Crutcho Creek surface water samples. Those compounds detected did not have associated Cancer Slope Factors for the route of exposure under consideration; hence, no incremental cancer risks are calculated.

Tributaries of Elm Creek

Hazard Indices for all locations were below unity for all potential residential exposures to surface water contaminants via ingestion. Therefore, the onset of toxic effects on exposure is not expected. While acetone and 4-methyl-2-pentanone were detected in the most recent sample collected from Location 22, it is arsenic that is the primary contributor to the calculated Hazard Index.

No incremental cancer risks were estimated for the sampled locations at the creek because no CSFs are available for the analytes detected.

6.5.1.2 Adolescent Swimmers via Incidental Ingestion and Dermal Absorption

A summary of Hazard Indices and incremental cancer risks for adolescent exposures to surface water while swimming is shown in Table 6-6.

TABLE 6-6

HAZARD INDICES AND INCREMENTAL CANCER RISKS[1]
SURFACE WATER EXPOSURES – ADOLESCENT SWIMMERS VIA INCIDENTAL INGESTION AND DERMAL ABSORPTION
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sampling Station[2]	Incidental Ingestion		Dermal Absorption	
	Hazard Index	Incremental Cancer Risk	Hazard Index	Incremental Cancer Risk
KUHLMAN CREEK				
SW01	1.7×10^{-3}	1.2×10^{-9}	4.7×10^{-4}	3.3×10^{-10}
SW02	2.4×10^{-3}	----	6.6×10^{-4}	----
SW03	1.3×10^{-3}	----	3.6×10^{-4}	----
SW04	2.3×10^{-3}	----	6.3×10^{-4}	----
SW05	1.2×10^{-3}	----	3.4×10^{-4}	----
SW27	1.3×10^{-3}	----	3.5×10^{-4}	----
CRUTCHO CREEK				
SW06	2.7×10^{-3}	----	7.4×10^{-4}	----
SW07	2.2×10^{-3}	----	6.0×10^{-4}	----
SW08	2.5×10^{-3}	----	6.9×10^{-4}	----
SW09	2.2×10^{-3}	----	6.2×10^{-4}	----
SW10	2.3×10^{-3}	----	6.4×10^{-4}	----
SW11	1.1×10^{-3}	----	2.9×10^{-4}	----
SW12	1.1×10^{-3}	----	3.0×10^{-4}	----
SW13	2.4×10^{-3}	----	6.7×10^{-4}	----
SW14	1.5×10^{-3}	----	4.1×10^{-4}	----
SW15	2.2×10^{-3}	----	6.0×10^{-4}	----
SW16	1.7×10^{-3}	----	4.7×10^{-4}	----
SW17	1.2×10^{-3}	----	3.3×10^{-4}	----
SW18	1.0×10^{-3}	----	2.8×10^{-4}	----
SW19	1.4×10^{-3}	----	4.0×10^{-4}	----
SW20	7.8×10^{-4}	----	2.1×10^{-4}	----
SW21	8.4×10^{-4}	----	2.3×10^{-4}	----
SW25	1.5×10^{-3}	----	4.1×10^{-4}	----
SW26	5.4×10^{-4}	----	1.5×10^{-4}	----
ELM CREEK				
SW22	1.5×10^{-3}	----	4.2×10^{-4}	----
SW23	1.2×10^{-3}	----	3.3×10^{-4}	----
SW24	1.4×10^{-3}	----	3.8×10^{-4}	----

(1) Hazard Quotients and Incremental Cancer Risks for specific chemicals presented in Appendix G.
(2) SW - indicates surface water sample.

Kuhlman Creek

Estimated Hazard Indices at all sampled stations were several orders of magnitude below unity for both incidental ingestion and dermal absorption. Again, arsenic, barium, and lead were the largest contributors to these risks.

Only one of the six stations at Kuhlman Creek posed potential incremental cancer risks. The estimated cancer risks for Location 1, which were well below the USEPA risk goal of 10^{-6}, were 1.2 x 10^{-9} for incidental ingestion and 3.3 x 10^{-9} for dermal absorption. The sole source of the risk was bis(2-ethylhexyl)phthalate at an average concentration of 5.4 ug/l.

Crutcho Creek

All of the Hazard Indices for Crutcho Creek were less than 1.0, thereby indicating that no adverse noncarcinogenic health effects are expected for adolescent swimmers. All Hazard Indices were on the order of 10^{-3} to 10^{-4}, with barium and lead identified as the primary noncarcinogens of concern in this creek.

No incremental cancer risks were estimated for the sampled locations at the creek since none of the chemicals detected have associated Cancer Slope Factors.

Tributaries of Elm Creek

Hazard Indices for both exposure routes were also below unity at every location in Elm Creek. Again, all Hazard Indices were in the range of 10^{-3} to 10^{-4}.

No carcinogenic health effects are anticipated as a result of surface water exposures in Elm Creek.

6.5.1.3 Adult Fishermen via Ingestion of Fish

Table 6-7 defines the Hazard Indices and incremental cancer risks for adult fishermen exposed to surface water contaminants by way of fish ingestion.

Kuhlman Creek

All Hazard Indices associated with fish ingestion were below unity, thus indicating that no adverse noncarcinogenic health effects are anticipated at any sampled location. Arsenic was the most

TABLE 6-7

HAZARD INDICES AND INCREMENTAL CANCER RISKS(1)
SURFACE WATER EXPOSURES – ADULT FISHERMEN VIA INGESTION OF FISH
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

Sampling Station(2)	Adult Fisherman - Ingestion of Fish	
	Hazard Index	Incremental Cancer Risk
KUHLMAN CREEK		
SW01	1.6×10^{-1}	1.6×10^{-6}
SW02	1.3×10^{-1}	----
SW03	4.1×10^{-3}	----
SW04	1.6×10^{-1}	----
SW05	6.4×10^{-2}	----
SW27	9.4×10^{-2}	----
CRUTCHO CREEK		
SW06	1.4×10^{-1}	----
SW07	1.5×10^{-1}	----
SW08	1.6×10^{-1}	----
SW09	1.4×10^{-1}	----
SW10	1.3×10^{-1}	----
SW11	3.3×10^{-3}	----
SW12	3.7×10^{-3}	----
SW13	1.2×10^{-1}	----
SW14	5.1×10^{-3}	----
SW15	9.1×10^{-2}	----
SW16	5.3×10^{-3}	----
SW17	3.7×10^{-3}	----
SW18	9.5×10^{-3}	----
SW19	4.5×10^{-3}	----
SW20	5.6×10^{-3}	----
SW21	6.3×10^{-3}	----
SW25	8.3×10^{-2}	----
SW26	3.2×10^{-3}	----
ELM CREEK		
SW22	5.2×10^{-2}	----
SW23	7.3×10^{-2}	----
SW24	8.1×10^{-2}	----

(1) Hazard Quotients and Incremental Cancer Risks for specific chemicals presented in Appendix G.

(2) SW - indicates surface water sample

significant contributor to the calculated Hazard Indices, followed by the phthalate esters found at Location 1.

Bis(2-ethylhexyl)phthalate, detected at Location 1, was the only chemical of concern at Kuhlman Creek that posed an incremental cancer risk for fish ingestion. The incremental cancer risk (worst-case scenario) for this location was 1.6×10^{-6}, which is well within the USEPA risk range goal of 10^{-4} to 10^{-6}.

Crutcho Creek

Hazard Indices for ingestion of fish were below unity for every location at Crutcho Creek. Barium was the most significant factor in the estimated risks. Acetone and 4-methyl-2-pentanone, which were found during the most recent sampling round, are not highly bio-accumulative.

None of the sampled locations have estimated incremental cancer risks since no Cancer Slope Factors are documented for oral exposure to the chemicals found in the surface waters in Crutcho Creek.

Tributaries of Elm Creek

Adverse noncarcinogenic health effects are not expected from fish ingestion at Elm Creek because all calculated Hazard Indices were below unity for the sampled locations. The Hazard Index is 5.2×10^{-2} for location 22, 7.3×10^{-2} for Location 23, and 8.1×10^{-2} for Location 24. Arsenic, lead, and zinc are the primary metals of concern.

As was the case with Crutcho Creek, no incremental cancer risks were estimated for the sampled locations at the creek because none of the metals present have calculated CSFs via oral exposure.

6.5.2 Sediment Exposure

This section summarizes the risks resulting from sediment exposure for a particular sampled location. The chemical-specific risks per location are listed in Appendix G.

6.5.2.1 Adolescent Swimmers via Incidental Ingestion and Dermal Absorption

Hazard Indices and incremental cancer risks for adolescent swimmers exposed to sediment contaminants via incidental ingestion and dermal absorption are presented in Table 6-8.

TABLE 6-8

HAZARD INDICES AND INCREMENTAL CANCER RISKS[1]
SEDIMENT EXPOSURES – ADOLESCENT SWIMMERS VIA
INCIDENTAL INGESTION AND DERMAL ABSORPTION
TINKER AIR FORCE BASE, OKLAHOMA CITY, OKLAHOMA

Sampling Station[2]	Incidental Ingestion		Dermal Absorption	
	Hazard Index	Incremental Cancer Risk	Hazard Index	Incremental Cancer Risk
KUHLMAN CREEK				
SD01	6.1×10^{-3}	2.3×10^{-8}	1.6×10^{-5}	1.7×10^{-7}
SD02	1.4×10^{-3}	----	----	----
SD03	1.4×10^{-3}	----	----	----
SD04	2.8×10^{-3}	----	----	----
SD05	5.2×10^{-3}	4.9×10^{-9}	7.2×10^{-6}	4.1×10^{-8}
CRUTCHO CREEK				
SD06	5.1×10^{-3}	----	1.1×10^{-6}	----
SD07	1.4×10^{-3}	----	----	----
SD08	2.3×10^{-3}	----	----	----
SD09	1.6×10^{-3}	----	----	----
SD10	2.5×10^{-3}	----	----	----
SD11	1.3×10^{-3}	6.5×10^{-12}	1.5×10^{-6}	5.5×10^{-11}
SD12	4.0×10^{-3}	----	----	----
SD13	1.2×10^{-3}	2.7×10^{-8}	----	----
SD14	1.6×10^{-3}	----	----	----
SD15	3.7×10^{-3}	2.7×10^{-11}	----	2.3×10^{-10}
SD16	2.4×10^{-3}	----	----	----
SD17	1.6×10^{-3}	----	----	----
SD18	1.6×10^{-3}	----	----	----
SD19	2.4×10^{-3}	----	----	----
SD20	1.2×10^{-3}	----	----	----
SD21	1.2×10^{-3}	----	----	----
SD25	5.0×10^{-3}	----	----	----
SD26	1.2×10^{-2}	----	----	----
ELM CREEK				
SD22	3.1×10^{-3}	----	----	----
SD23	1.7×10^{-3}	----	----	----
SD24	3.0×10^{-3}	----	----	----

(1) Hazard Quotients and Incremental Cancer Risks for specific chemicals presented in Appendix G.

(2) SD - indicates sediment sample.

Kuhlman Creek

Hazard Indices for all locations at Kuhlman Creek were several orders of magnitude below unity for both exposure routes (between 10^{-3} and 10^{-6}). Calculated Hazard Indices associated with incidental ingestion were greater than those for dermal absorption, primarily because metals in soil/sediment are assumed to not be dermally absorbed.

No carcinogenic health effects are expected from swimming at the sampled locations as all cancer risks were below the USEPA risk goal of 10^{-6}. The estimated incremental cancer risk at Location 1 was 2.3×10^{-8} for incidental ingestion and 4.9×10^{-9} at Location 5. The incremental cancer risk for dermal absorption was 1.7×10^{-7} for Location 1, and 4.1×10^{-8} for Location 5. All other locations had no associated risks because only metals were detected, and these metals do not have cancer slope factors for the oral route of exposure.

Crutcho Creek

All Hazard Indices for incidental ingestion of and dermal contact with sediment were all below unity for Crutcho Creek (10^{-2} to 10^{-6}). Lead was a significant contributor to this risk (Location 26), while barium was significant at several other locations. Because metals are assumed to not be dermally absorbed from soil, the only noncarcinogens for the dermal route of exposure are di-n-butylphthalate (Location 6) and bis (2-ethylhexyl) phthalate (Location 11).

All incremental cancer risks for both exposure routes were well below the USEPA risk goal of 10^{-6}. Only Locations 11, 13, and 15 had incremental cancer risks for incidental ingestion, with the largest risk of 2.7×10^{-8} at Location 13, because of the detection of beryllium at a concentration 1.0 mg/kg. Estimated cancer risks for dermal absorption also were calculated for Locations 11 and 15 (5.5×10^{-11} and 2.3×10^{-10}, respectively), where samples were found to contain bis(2-ethylhexyl)phthalate and 4,4'-DDD. No carcinogenic risks were indicated for the remaining locations because the detected contaminants are not carcinogenic via ingestion.

Tributaries of Elm Creek

Adolescent swimmers exposed to sediment contaminants are unlikely to experience any adverse noncarcinogenic health effects at Elm Creek because estimated Hazard Indices were below unity. No risks were associated with dermal absorption of sediment contaminants since only inorganics were found. Metals are not a factor in determining incremental risks for dermal absorption of sediment

because these chemicals are not readily absorbed through the skin. Barium, arsenic, lead, manganese, and vanadium were the primary sources of the risk.

Additionally, no cancer risks were estimated for incidental ingestion as none of the contaminants detected are carcinogenic via this route of exposure.

6.5.3 Summary of Total Hazard Indices and Cancer Risks

Maximum total carcinogenic and noncarcinogenic risks calculated in Section 6.5 are summarized in this section. These risks have been summarized for each creek.

6.5.3.1 Kuhlman Creek

Table 6-9 contains a summary of the maximum total carcinogenic and noncarcinogenic risks for all receptor exposures to surface waters and sediment at Kuhlman Creek. The maximum noncarcinogenic risks for exposure to surface water, with the exception of the risk for adult fishermen, were calculated for Location 2. The maximum noncarcinogenic risk for ingestion of fish were calculated for Locations 1 and 4. The maximum noncarcinogenic risks for exposure to sediment were calculated for Location 1. The maximum carcinogenic risks for exposure to both surface water and sediment were calculated for Location 1.

6.5.3.2 Crutcho Creek

A summary of the maximum total carcinogenic and noncarcinogenic risks for surface water and sediment exposures at Crutcho Creek are presented in Table 6-10. Maximum Hazard Indices for surface water exposures via ingestion and swimming are calculated for Location 6. The Maximum Hazard Index for ingestion of fish was calculated for Location 8. Maximum noncarcinogenic risks for sediment exposures are estimated for Location 26 (incidental ingestion) and Location 11 (dermal absorption). The maximum carcinogenic risks for sediment exposure were calculated at Location 13 (incidental ingestion) and Location 15 (dermal adsorption).

6.5.3.3 Tributaries of Elm Creek

Table 6-11 summarizes the maximum total carcinogenic and noncarcinogenic risks for all receptors exposed to contaminants in the surface waters and sediment at the tributaries of Elm Creek. The maximum risks, except for the noncarcinogenic risk associated with fish ingestion, were calculated for Location 22. The Maximum Hazard Index associated with fish ingestion was calculated for Location 24.

TABLE 6-9

MAXIMUM TOTAL HAZARD INDICES AND CANCER RISKS
KUHLMAN CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

	Maximum Hazard Index				Maximum Cancer Risk		
	Adult Resident	Child Resident	Adolescent	Adult Fisherman	Adult Resident	Adolescent	Adult Fisherman
Ingestion of surface water for potable water supply	5.3×10^{-1}	1.2×10^{0}[a]	NA	NA	8.9×10^{-7}	NA	NA
Incidental ingestion of surface water	NA	NA	2.4×10^{-3}	NA	NA	1.2×10^{-9}	NA
Dermal absorption of surface water	NA	NA	6.6×10^{-4}	NA	NA	3.3×10^{-9}	NA
Ingestion of fish	NA	NA	NA	1.6×10^{-1}	NA	NA	1.6×10^{-6}
MAXIMUM TOTAL HAZARD INDEX/ CANCER RISK (SURFACE WATER)	**5.3×10^{-1}**	**1.2×10^{0}[a]**	**3.1×10^{-3}**	**1.6×10^{-1}**	**8.9×10^{-7}**	**4.5×10^{-9}**	**1.6×10^{-6}**
Incidental ingestion of sediment	NA	NA	6.1×10^{-3}	NA	NA	2.3×10^{-8}	NA
Dermal absorption of sediment	NA	NA	1.6×10^{-5}	NA	NA	1.7×10^{-7}	NA
MAXIMUM TOTAL HAZARD INDEX/ CANCER RISK (SEDIMENT)	**NA**	**NA**	**6.1×10^{-3}**	**NA**	**NA**	**1.9×10^{-7}**	**NA**

NA Not applicable; exposure route not evaluated.
(a) See Section 6.5.1.1 for a discussion of the significance of this Hazard Index.

TABLE 6-10

MAXIMUM TOTAL HAZARD INDICES AND CANCER RISKS
CRUTCHO CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

	Hazard Index				Cancer Risk		
	Adult Resident	Child Resident	Adolescent	Adult Fisherman	Adult Resident	Adolescent	Adult Fisherman
Ingestion of surface water for potable water supply	5.7×10^{-1}	1.3×10^{0}(a)	NA	NA	----	NA	NA
Incidental ingestion of surface water	NA	NA	2.7×10^{-3}	NA	NA	----	NA
Dermal absorption of surface water	NA	NA	7.4×10^{-4}	NA	NA	----	NA
Ingestion of fish	NA	NA	NA	1.6×10^{-1}	NA	NA	----
MAXIMUM TOTAL HAZARD INDEX/ CANCER RISK (SURFACE WATER)	**5.7×10^{-1}**	**1.3×10^{0}(a)**	**3.4×10^{-3}**	**1.6×10^{-1}**	**----**	**----**	**----**
Incidental ingestion of sediment	NA	NA	1.2×10^{-2}	NA	NA	2.7×10^{-8}	NA
Dermal absorption of sediment	NA	NA	1.5×10^{-6}	NA	NA	2.3×10^{-10}	NA
MAXIMUM TOTAL HAZARD INDEX/ CANCER RISK (SEDIMENT)	**NA**	**NA**	**1.2×10^{-2}**	**NA**	**NA**	**2.7×10^{-8}**	**NA**

NA Not applicable; exposure route not evaluated.
(a) See Section 6.5.1.1 for a discussion of the significance of this Hazard Index.
---- No carcinogenic effects via this route of exposure

TABLE 6-11

MAXIMUM TOTAL HAZARD INDICES AND CANCER RISKS
TRIBUTARIES OF ELM CREEK
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

	Hazard Index				Cancer Risk		
	Adult Resident	Child Resident	Adolescent	Adult Fisherman	Adult Resident	Adolescent	Adult Fisherman
Ingestion of surface water for potable water supply	3.4×10^{-1}	7.8×10^{-1}	NA	NA	----	NA	NA
Incidental ingestion of surface water	NA	NA	1.5×10^{-3}	NA	NA	----	NA
Dermal absorption of surface water	NA	NA	4.2×10^{-4}	NA	NA	----	NA
Ingestion of fish	NA	NA	NA	8.1×10^{-2}	NA	NA	----
MAXIMUM TOTAL HAZARD INDEX/ CANCER RISK (SURFACE WATER)	**3.4×10^{-1}**	**7.8×10^{-1}**	**1.9×10^{-3}**	**8.1×10^{-2}**	**----**	**----**	**----**
Incidental ingestion of sediment	NA	NA	3.1×10^{-3}	NA	NA	----	NA
Dermal absorption of sediment	NA	NA	----	NA	NA	----	NA
MAXIMUM TOTAL HAZARD INDEX/ CANCER RISK (SEDIMENT)	**NA**	**NA**	**3.1×10^{-3}**	**NA**	**NA**	**----**	**NA**

NA Not applicable; exposure route not evaluated.
---- No carcinogenic effects via this exposure route.

6.6 OKLAHOMA WATER QUALITY CRITERIA

This section presents an evaluation of surface water contaminants at Kuhlman and Crutcho Creek, and tributaries of Elm Creek in relation to state water quality criteria. The three potential scenarios for surface water use with applicable water quality numerical criteria are as follows:

- Surface water designated as public and private water drinking supplies.
- Surface water used as potable water supplies and fishing activities.
- Surface water only used to support warm and cool water aquatic communities.

Each of the surface water scenarios will be discussed independently.

6.6.1 Public and Private Drinking Water Criteria

Surface waters designated as drinking water supplies for public and private use are required to meet Oklahoma raw water numerical criteria for certain substances. Based on (1) a comparison of detected contamination at Kuhlman and Crutcho Creeks and tributaries of Elm Creek and (2) water criteria, levels of bis(2-ethylhexyl)phthalate and di-n-octylphthalate found at Kuhlman Creek slightly exceed the 3 ug/l numerical criteria for phthalate esters. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected at average concentrations of 5.4 ug/l and 8.4 ug/l, respectively at Location 1. The detected concentration of chlorphyrifos (6.1 ug/l) found in one surface water sample at Location 1 on Kuhlman Creek did exceed the numerial criteria (Acute, 0.083 ug/l and Chronic, 0.041 ug/l) for toxic substances for the protection of fish and wildlife.

Note that phthalate esters are used in the production of plastics and are ubiquitous environmental contaminants and are common laboratory artifacts. The presence of these phthalate esters in Kuhlman Creek is not considered indicative of poor or inadequate waste management/handling practices at Tinker AFB. Furthermore, the indicated exceedances are not considered to be significant since Kuhlman Creek is not a source of drinking water.

6.6.2 Fish Ingestion and Drinking Water Water Criteria

A separate, more restrictive set of water quality standards for specific chemicals is applicable for receptors exposed to surface water contaminants via ingestion of fish and water. Detected

concentrations of arsenic at all creeks as well as lead at many locations in Kuhlman and Crutcho Creeks failed to meet the established quality standards of 0.175 ug/l for arsenic and 5.0 ug/l for lead. Average concentrations of arsenic found in the creeks range from 1.0 to 2.8 ug/l, while the highest average concentration of lead is 7.5 ug/l detected at Location 3 in Kuhlman Creek.

Of the three creeks studied, only tributaries of Elm Creek, which flows into a water supply reservoir, is used as a source of drinking water and fishing. As a result of the high levels of arsenic and lead in background sediments and the intermittent nature of the creeks and tributaries, the exceedances are not felt to be indicative of site-specific contamination.

6.6.3 Water Criteria for the Consumption of Fish

This is another list of water quality criteria that is designated for the protection of human health for the consumption of fish. Arsenic is the only chemical exceeding the numerical standard for surface waters. Levels of arsenic in Kuhlman and Crutcho Creeks and the tributaries of Elm Creek exceeded the 1.399 ug/l criteria.

All of the studied creeks and tributaries at Tinker Air Force Base support limited warm water aquatic communities. However, the exceedances are not considered indicative of site-specific contamination, but may reflect regional use of arsenical pesticides and naturally occurring background levels of arsenic.

6.7 SUMMARY AND CONCLUSIONS

The following is a discussion of the major noncarcinogenic and carcinogenic risks and water quality exceedances. Final conclusions are also presented in this section.

Hazard Indices associated with the ingestion of surface water by child residents for Locations 2 and 4 in Kuhlman Creek and Locations 6, 7, 8, 9, 10, 13, and 15 in Crutcho Creek exceeded unity. Arsenic, barium, and lead contributed to the risks at all locations, while cobalt, mercury, and zinc contributed at several locations. Barium was the most significant contributor to the risks at all locations.

Note that barium sulfate reportedly occurs naturally in the vicinity of Tinker AFB and that barium is not known to have been used at the facility. Therefore, it is considered likely that the noncarcinogenic risks associated with barium are indicative of naturally occurring conditions.

Furthermore, it is important to note that the three major contributors to the Hazard Index at all of the sampling locations are arsenic, barium, and lead. These inorganic elements have distinctly different toxic effects, as follows (USEPA, January 1991):

- arsenic - Keratosis and hyperpigmentation
- barium - Fetotoxicity and increased blood pressure
- lead - Central nervous system effects

As per current EPA guidance, to arrive at a truly representative Hazard Index, the toxic endpoints of the individual chemicals should be considered and only those with similar effects should be treated additively. Therefore, since the effects are markedly dissimilar for these three chemicals, it is concluded that the Hazard Indices slightly greater than 1.0 (e.g., 1.1 to 1.3) are not indicative of potential adverse health effects even under the conservative exposure assumptions used for this analysis.

The only incremental cancer risk greater than the USEPA risk goal of 10^{-6} was the estimated risk associated with surface water exposure via fish ingestion for Location 1 at Kuhlman Creek. The incremental cancer risk (1.6×10^{-6}) exceed the risk goal but was within the range of 10^{-4} to 10^{-6}, which is typically considered to be acceptable for RCRA/CERCLA activities. The sole source of the risk was bis(2-ethylhexyl)phthalate.

The concentrations of bis(2-ethylhexyl)phthalate and di-n-octylphthalate found at location 1 in Kuhlman Creek exceeded the state water quality criteria for waters used as only public and private water supplies. The concentration of chlorpyrifos at Location 1 in Kuhlman Creek exceeded the state water quality criteria for the protection of fish and wildlife. Detected concentrations of lead at several locations in Kuhlman and Crutcho Creeks failed to meet the numerical criteria associated with surface waters designated for fishing and as potable water supplies. Arsenic was the only compound detected that exceeded state water quality criteria for the beneficial uses of Crutcho and Kuhlman Creeks and the tributaries of Elm Creek identified in Oklahoma's Water Quality Standards. Arsenic exceeded the water quality standards designed to protect human health for consumption of fish and for the consumption of fish and potable water use. Phthalate esters and lead exceeded state water quality criteria for hypothetical uses considered by the risk assessment.

This risk assessment was conducted in a conservative (worst-case) approach. Most of the exposure routes considered were hypothetical and not based on actual surface water usage. Kuhlman and Crutcho Creeks are not designated as potable water supplies and the intermittent nature of all three creeks and tributaries makes sport fishing exposures unlikely. The tributaries of Elm Creek flow into a

water supply reservoir fed by other surface streams, groundwater, and rainfall that will dilute the contamination found at the sampled locations along this creek.

Finally, contamination was detected at several discrete locations along the studied creeks and tributaries, thus indicating the absence of widespread surface water and sediment contamination in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek.

7.0 FINDINGS AND RECOMMENDATIONS

The findings of the investigation of Crutcho and Kuhlman Creeks and the tributaries of Elm Creek are summarized in Section 7.1, Surface Water Investigation Findings, and Section 7.2, Sediment Investigation Findings. Recommendations based on these findings are summarized in Section 7.3.

7.1 SURFACE WATER INVESTIGATION FINDINGS

The surface water in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek did not contain significant quantities of VOC or SVOC compounds. No VOCs or SVOCs were detected in Crutcho Creek or the tributaries of Elm Creek in July 1991 or February 1992. One VOC (xylene) was detected at one location on Kuhlman Creek and two SVOCs (phthalate esters) were also present at one location in Kuhlman Creek in February 1992. Both the VOC and SVOCs were present at low concentrations. One of the SVOCs, bis(2-Ethylhexyl)phthalate, was detected at 6J ug/l which is above the MCL of 4 ug/l. Two VOCs, acetone and 4-Methyl-2-pentanone, were detected at low levels in all May 1992 samples.

Pesticides and PCBs were not found in any surface water samples collected in July 1991 and February 1992 or in the majority of samples in May 1992. One sample location on Kuhlman Creek contained a low level of the pesticide, chlorpyrifos (6.1 ug/l). This concentration exceeded Oklahoma's water quality criteria for the protection of fish and wildlife. The source of this pesticide was identified by base personnel as being a construction site pretreated for insect control by a construction subcontractor in early May 1992. Heavy rains following application of the insecticide are believed to have transported the chlorpyrifos into a tributary of Kuhlman Creek. Radioactivity (gross alpha and beta) was not elevated above background levels in any samples.

Inorganics were found in most surface water samples collected from all three creeks and tributaries. Elevated levels of arsenic, barium, lead, cobalt, and zinc were detected at several locations. The elevated levels of barium are thought to be due to naturally occurring barium sulfate, since the background samples collected on Crutcho Creek contained high levels of barium.

Arsenic concentrations exceed the Oklahoma Water Quality Standard criteria for the consumption of fish (1.399 ug/l) at several locations in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek. Arsenic concentrations detected in the tributaries of Elm Creek also exceeded Oklahoma's water quality criteria for fish ingestion and potable water use (0.175 ug/l). Since the average background level of arsenic was measured to be 1.15 ug/l, these exceedances are not felt to be indicative of site-

specific contamination but may reflect regional use of arsenical pesticides and naturally occurring background levels.

The results of the risk assessment for surface water scenarios did not indicate any unacceptable carcinogenic or noncarcinogenic risks associated with the designated beneficial uses of Crutcho and Kuhlman Creeks or the tributaries of Elm Creek. The Total Hazard Index associated with the ingestion of surface water by child residents (1.2×10^{0}) exceeded unity at several locations on Crutcho and Kuhlman Creeks. However, these are hypothetical risks not based on the designated uses of these streams, since these streams are not classified for use as potable water supplies (Oklahoma Water Quality Standard). In addition, since the individual Hazard Indices associated with all target organs was less than unity and the largest component of the total hazard index is associated with what is thought to be naturally occurring barium, these indices are not considered indicative of unacceptable noncarcinogenic health risks. The highest incremental cancer risk calculated (1.6×10^{-6}) for the surface water scenarios was for ingestion of fish at Location 1 on Kuhlman Creek. The sole source of this risk was bis(2-ethyhexyl)phthalate. This risk is well within the USEPA risk range goal of 10^{-4} to 10^{-6} and is based on a worst-case scenario. The worst-case scenario does not take into consideration the size of the stream and its limited fish population. Subsequently, no unacceptable carcinogenic risks are expected for this exposure scenario.

7.2 SEDIMENT INVESTIGATION FINDINGS

The sediment in Crutcho Creek and the tributaries of Elm Creek did not contain significant quantities of SVOCs, pesticides, or PCBs. PCBs were not found in either creek. However, 4,4 DDD, a pesticide, was found at low concentrations (18 ug/kg) at one location on Crutcho Creek. In addition, SVOCs were found at two locations on Crutcho Creek. One location is at the entry of a tributary of Crutcho Creek onto the base and the other location is at the point where Crutcho Creek leaves the base. Only one phthalate ester at low concentrations was detected at each location.

The sediment in Kuhlman Creek contains low levels of SVOCs, primarily PAH compounds. These PAHs probably are the result of past fuel (JP-4) spills or leaks as evidenced by the hydrocarbon-contaminated booms in the creek and the soil staining observed near several of the storm sewer outfalls.

The sediment at one location on Kuhlman Creek also contained a PCB compound. No pesticides were found in the sediment of Kuhlman Creek.

Low-to-moderate concentrations of inorganics were found in all sediment samples. Arsenic, barium, chromium, copper, lead, vanadium, and zinc were the inorganics detected most often. These inorganics were also detected in the two background samples collected from Crutcho Creek. The elevated concentrations of barium are thought to be due to naturally occurring barium sulfate because the background samples also contained elevated levels of barium.

The risk assessment results indicated that the sediment of Crutcho and Kuhlman Creeks and the tributaries of Elm Creek do not pose unacceptable carcinogenic or noncarcinogenic health risks through the evaluated sediment exposures.

7.3 RECOMMENDATIONS

The observations and findings of this investigation to characterize the nature and extent of sediment and surface water contamination in Crutcho and Kuhlman Creeks and the tributaries of Elm Creek provide the rationale for the following recommendations:

- A surface water monitoring program should be established to sample Crutcho and Kuhlman Creeks both upstream and downstream of base boundaries. Periodic monitoring of these locations will identify significant changes in water quality and will document if the changes are due to activities at Tinker AFB or are due to off-base sources.

- An oil/water separator, a surface water detention structure or other spill containment measures should be considered for use on Crutcho and Kuhlman Creeks. The construction of the Navy Facility in the Crutcho Creek drainage area increases the potential for a future spill or leak that could cause off-site damages. On Crutcho Creek, one of the existing concrete floodwater detention structures could potentially be used for this purpose.

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